

FINAL REPORT ON FOREST ECOLOGICAL STRATIFICATION IN VIETNAM

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Despite considerable efforts made by the research team, it would be hard to avoid limitations and oversights due to time and resources constraints. We, therefore, look forward to having further contribution from various agencies and experts for improvement of forest ecological stratification.

Abbreviations

C & I	Ecological criteria and Indicator for stratification
COP	Conference of Parties
ĐDSH	Biodiversity
ĐTQHR	Forest inventory and planning
FAO	World Food Agriculture Organization
FSIV	Forest Science Institute of Vietnam
GHGs	Green house gas
HST	Ecosystem
HSTR	Forest ecosystem
IPCC	International Panel on Climate change
IUCN	International Union for Conservation of Nature
KHNN	Agricultural climate
LHQ	United Nations
MRV	Measurment, reporting and verification
NN-PTNT	Agriculture and rural development
REDD	Reducing emission from deforestation and degradation
REL	Reference emission level
RCFEE	Research Center on Forest ecology and Environment
RTN	Natural forest
RT	Plantation forest
STLN	Forest ecology
TCLN	Administration of Forestry (VNForest)
UBND	People's Committee
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United nation framework Convention on Climate change
UNDP	United nation Development Program
UNEP	United Nation Environmental Program
UN-REDD	United Ntion program on reducing emission from deforestation and degradation
WWF	World wide fund for Nature

Executive summary

REDD was initiated and formally adopted as a commodity for climate change mitigation. Although forest loss due to deforestation and forest conversion is continuing to take place in a numbers of countries, but forest cover in Vietnam has been increasing dramatically for the past 20 years. Thus, Vietnam is known a country potential for REDD implementation. In the UN-REDD Program, Vietnam is targeting to use Tier 2 for piloting phase and Tier 3 for REDD credit phase.

Currently Vietnam uses an ecological zoning system which was primarily established as an agro-ecological zoning system with minor adaptations for the forestry sector. Therefore, to support development of REL/RL and implementation of MRV in REDD scheme in Vietnam, a study on forest ecological stratification was carried out under the cooperation between FAO, UN-REDD Vietnam and Research Centre for Forest Ecology and Environment of Forest Science Institute of Vietnam. The study involved a numbers of leading national specialists in the field of climate, forest ecology, soils, geology, GIS etc. The objective of the study was to stratify the Vietnam's territory into forest eco-regions by considering ecological factors that influence greatly the formation and productivity of forest vegetation types.

Literature review and expert method was employed to analyze and identify the relevant ecological factors to be used for forest ecological stratification in Vietnam. The study identified and used ecological factors and the hierarchy of such factors for the stratification. The climate factor, represented by temperature and sunshine hours factors are used to stratify ecological zone. Climate condition, topography, forest ecosystem and soils are factors that are used to stratify ecological regions and sub-regions with different details. The ecological sub-region is relatively homogenous area for climate condition, topography, soils and forest ecosystem.

The results of forest stratification identified 2 ecological zones, 8 ecological regions and 47 ecological sub-regions. The ecological zones are North and South with the boundary is Hai Van pass and Bach Ma Mountain ranges. The 8 ecological regions include Northeast, Northwest, Northern Delta, North Central Coast, South Central Coast, Central Highland, Southeast and Southwest. Ecological sub-regions are basic area to define the formation and productivity of forest types. There are 4 out of 47 ecological sub-regions are islands area. The ecological stratification maps were developed for whole country and 8 ecological regions. A detailed database on climate condition (temperature, rainfall), topography, soils, typical forest vegetation types and species was also developed for 8 ecological regions and 47 ecological sub-regions.

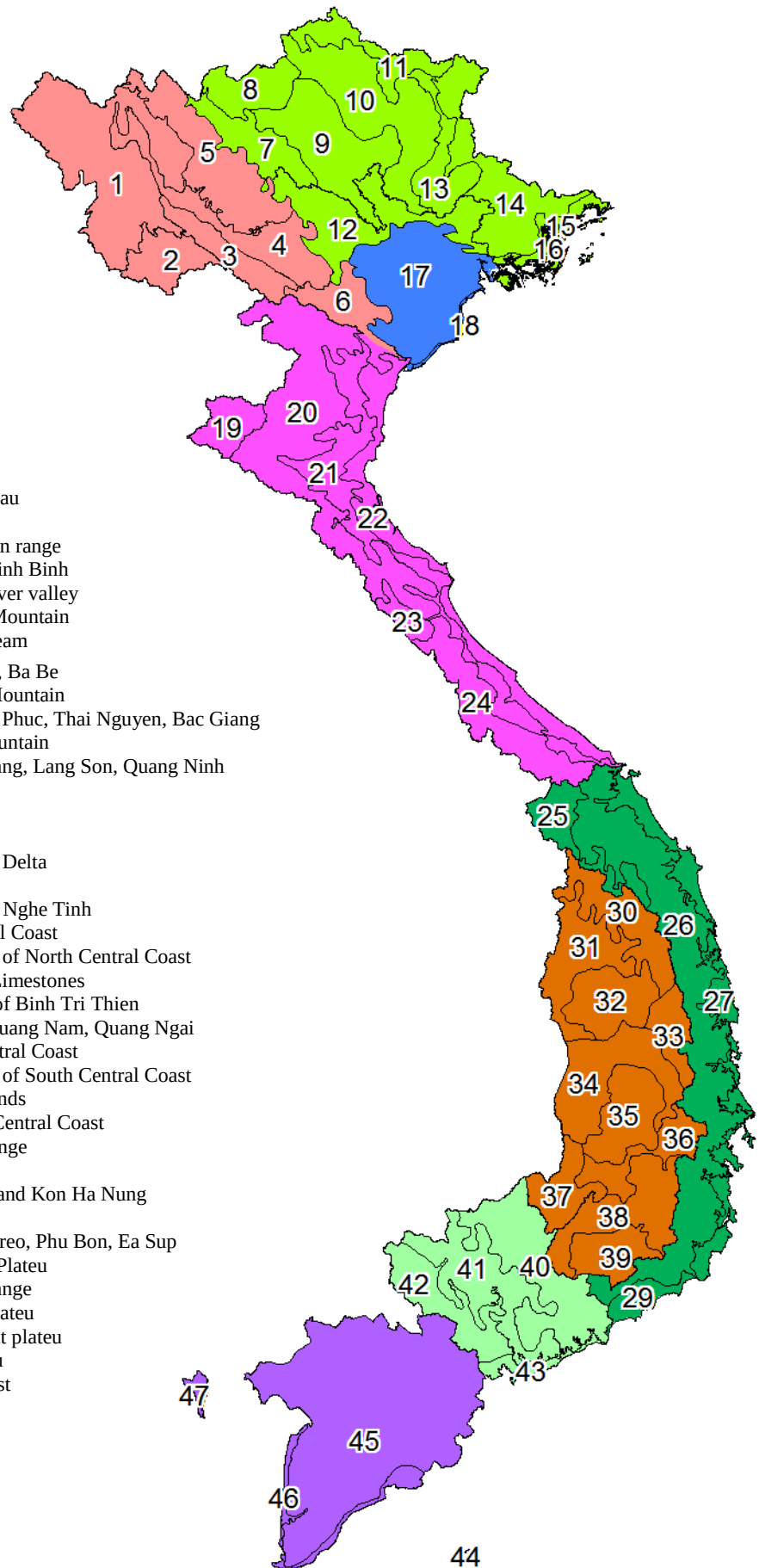
The results of this stratification are not aimed at supporting development of REL/RL and MRV in REDD activities particularly, but also is a good base for forestry management and development in general. It is recommended to use 8 ecological regions for REL/RL and MRV development for national scale and ecological sub-regions for sub-national REL/RL and MRV for REDD activities. However, due to limited time and resources, the results of stratification is not yet validated; therefore there is a need for further completion.

Regions

North West
North East
Northern Delta
Middle North
Middle South
Central Highland
South East
South East

Sub-regions

1: Da river upstream
2: Ma river upstream
3: Son La - Moc Chau plateau
4: Da river valley
5: Hoang Lien Son mountain range
6: Hill land of Hoa Binh, Ninh Binh
7: Hong River and Chay River valley
8: Hoang Su Phi medium Mountain
9: Lo and Gam rivers upstream
10: Low mountain Bao Lac, Ba Be
11: Dong Van Limestone Mountain
12: Hilland Phu Tho, Vinh Phuc, Thai Nguyen, Bac Giang
13: Bac Son Limestone Mountain
14: Low hill land of Cao Bang, Lang Son, Quang Ninh
15: Mangrove of Northeast
16: Northeast Islands
17: Northern Delta
18: Mangroves of Northern Delta
19: Muong Xen
20: West moutain of Thanh Nghe Tinh
21: Hilland of North Central Coast
22: Delta and coastal sandy of North Central Coast
23: Phong Nha - Ke Bang Limestones
24: West Mountain Range of Binh Tri Thien
25: Western Mountain of Quang Nam, Quang Ngai
26: Hilly area of South Central Coast
27: Delta and coastal sandy of South Central Coast
28: Paracel and Spratly Islands
29: Drought area of South Central Coast
30: Ngoc Linh Mountain range
31: Sa Thay low Mountain
32: Basalt Plateu of Pleiku and Kon Ha Nung
33: An Khe low Mountain
34: Peneplain area of Cheo reo, Phu Bon, Ea Sup
35: Buon Ma Thuot Basalt Plateu
36: Man Drack Mountain range
37: Dak Nong - Dak Min plateau
38: Chu Ang Sin and Da Lat plateau
39: Di Linh, Bao Loc plateau
40: Low Mountain Southeast
41: Hillland of Southeast
42: Southeast Delta
43: Mangrove of Southeast
44: Con Dao Islands
45: Mekong Delta
46: Mangrove of Southwest
47: Southwest Islands



1 Introduction

Increase in green house gas (GHG) emission has caused obvious global warming and climate change for recent years and is seen as global concerns. To reduce GHG emission world-wide, particularly carbon dioxide (CO₂) - on one hand - developed countries need to commit on emission reduction and on the other hand, and it is vitally important to protect forest, especially those in tropical countries where distributed large tropical forest areas and are seen as forest carbon sequestration and storage sink. Under such a perception, during the COP 13 taken place in Bali, Indonesia in December 2007, stakeholders endorsed Bali Action Plan, including the proposed roadmap on development and integration of REDD+ as an official mechanism among climate change mitigation measures in the future, particularly after the post-Kyoto Protocol in 2012. REDD+ stands for Reducing Emission from Deforestation and Forest Degradation.

In Vietnam, REDD+ readiness of the government is being supported by various international organizations including the UN-REDD programme involving three UN organizations, namely UNDP, FAO and UNEP. One of the main objectives of the UN-REDD program in Vietnam is supporting VNForest under MARD and focal agencies to establish and manage different tools for effective, transparent and equal implementation of REDD+ program. It also aims to ensure that focal agencies are capable to precisely measure reduced emission from deforestation and degradation while being in line with international standards.

Among activities related to calculation of reduced emission, the development of Reference Emission Level (REL) and Measurement, Reporting and Verification system (MRV) is very crucial. At national measurement level (Tier 1), calculation on carbon sequestration and emission is mainly based on ecological stratification data in terms of typical forest types in Vietnam. As different forest types located in an ecological stratification have a rather homogenous ecological productivity, we could preliminarily calculate national forest carbon sequestration/emission level in the forestry sector.

To date, there has not yet been any forest ecological stratification system in place in Vietnam. If any, it is forest type or vegetation classification without positioning its natural distribution, knowing its distribution center and scope, anticipating potential productivity of each region and each forest type. These questions are contents of forest ecological stratification, which aims to provide basis for REL and MRV development.

Prior to the existence of forest ecological stratification, forestry sector often use definition on establishment of the existing 8 forest economic zones, which emerged in early 70s of the

previous century to develop sector development strategy for 10, 15 year period or 5 year forest planning. Since 1990s, after merging various ministries as ministry of forestry, agriculture, water resources, forestry sector has effectively used 7 agricultural ecological zones with identified criteria in terms of topography, climate, land and forest types.

However, though having similar meaning regarding to distribution zone and agricultural production for domestic consumption, set of criteria and indicators on climate, hydro-meteorology, and land for agriculture ecological stratification differs from those in forest ecosystems. In addition, apart from producing products for consumption, forest also produce a more important product – its ecological and environmental services. REDD+ is seen as a mechanism to combat global climate change, to which Vietnam and the entire Mekong river basin is said to be the among the most vulnerable.

Though, field survey could not be conducted, this research - the first one focusing on forest ecology stratification in Vietnam under the context where primary forest ecosystem is under serious damage - has inherited various experiences and data from functional zoning results in Vietnam regarding to hydro-meteorology, soil-site, terrain-topography and agricultural ecology.

Expected output of this research is to develop scientific basis and propose “Criteria and Indicator” on ecological stratification in Vietnam in order to have relative homogeneity on forest types in each region. Such a relative homogeneity on forest types has a significant meaning in terms of reducing errors while increasing reliability on forest carbon measurement to have basis for REL development and MRV implementation.

Among the conventional methods that were selected and inherited, expert method proves very efficient but requires profound knowledgeable and qualified forest ecological experts.

2 Overview of relevant zoning

2.1 Territorial zoning

2.1.1 Legal basis

The state’s first legal basis on territorial zoning of various economic and professional sectors of 1960s, 1970s were Circular No. 193/UB/VP dated 11/2/1963 issued by economic zoning committee under the State Planning Committee and Decision No. 270/CP dated 30/9/1977 of the Government’s Council, now called Government guiding implementation of economic zoning according to the following specialized sectors as follows:

1. Economics
2. Physical geography

3. Engineering geology
4. Sector economics
5. Economic geography
6. Agricultural ecology
7. Other specialized economic sectors

Specialized sectors conducted zoning according to their respective objective(s) and its results have been used for many years. The following paragraph describes some sub-regions related to this research.

1) Economic sectors Zoning: The division of national territory on vertical basis into different economic zones, as a basis for the state to organize and management different sectors.

Economic sectors zoning aimed at determining key development direction of sectors in the region both currently and in future, appropriate combination between the sectors in planning and arrangement of the national economy management according to sectoral and territorial basis. Economic sector zoning is also seen as basis for economic regional planning.

There are two types of economic sector as industry and agriculture. Each type also split into different sub-sectors. For example, industry sector include coal, oil, gas mining and metallurgy while agricultural sector comprises other sub-sectors as cropping, livestock, etc.

2) Physical geography zoning: The physical geography specialize in studying and discovering homogeneous emerging based natural area systems and therefore, have its typical features which are not reiterated in the space.

There are 2 main emerging factors, one is geographical zone affected by uneven solar energy distribution on earth so as to create hot, moderate, cold belts as well as forest zone, savanna and wasteland. The other factor is non-geographical zone, which is affected by tectonically energy in soil, so as creating continents, mountains, highlands, plains as well as geographical-topographical regions divided in different countries.

In smaller geographical areas, there is unification of these 2 factors so as creating general high homogeneous territory. Physical geography zoning comprises both hierarchy stratification and classification steps. A part from the above mentioned general zoning, there are also different stratification and zoning in terms of geomorphology, hydro-meteorology, soil and organism, etc. These hierarchy units will supplement each other to increase both scientific and practical basis for individual zoning elements.

3) Economic geography zoning: Economic geography sector specializes in doing research, discovering or anticipating formation of complete economic zones with specialized production and general development functions. Based on the geographic distribution of economic zones, the state can fully grasp natural, economic, social potential of different territorial different parts in the country to identify socio-economic development strategies and programs.

There exists zoning of general economic geography, interdisciplinary studies detect areas of economic diversity, complexity, and geo-economic zoning by sectors such as agriculture, industry and tourism to identify narrow specialization areas.

4) Engineering geology zoning: Studied geography zoning according to engineering geology conditions. Hierarchy zoning was employed, including zones – according to tectonic area; regions – according to geomorphology; unit – according to distribution of complex stratification and origin; compartment – according to one among other typical characteristics: phenomenon and geological processes, hydrogeology, physical properties of gravelly soil, etc.

Considering the combination of engineering geology to assess advantages of individual hierarchy classification in construction sector. It is up to scale of the developed map and territorial characteristics, it is possible to further break down the above mentioned hierarchy or merge them together. Zoning map is developed separately or together on engineering geology maps.

5) Hydro-meteorology zoning: Hierarchy classification system of climate zoning is based on 2 typical features. One is temperature resource division and the other is moisture resource division. Currently, 2 common hierarchies zoning are employed, including climatic zone and climatic region (Nguyen Duc Ngu, 2008).

- Climatic zone: following temperature resource (amplitude/year, total radiation/year); currently, there are 2 zones (north and south).
- Climatic region: On each zone, according to rainy, moisture criteria (rainy season, the 3 highest rainfall months), 7 hydro-meteorology regions are as follows: Northwest, northeast, red river delta, north-central, south-central, central highland and south.

6) Agro-ecological zoning: MARD divided Vietnam's territory into seven regions serving agricultural development and planning. The agro-ecological regions including Central and mountainous north; Red river delta; north-central coast; coastal southern; Central Highlands; Southeast and Mekong Delta.

Thus there are differences in the distribution of territory along the specialization versus agriculture or forestry ecological regions that under the research scope, including title of fundamental hierarchy as region: for example: Northern Plains or the Red River Delta, as in the region includes as well Thai Binh river system.

2.1.2 Hierarchy stratification and title

Yet, there is no consensus on title, number and definition of various hierarchy stratification not only because of regional zoning objective but its dependence on author(s)' perspective and methodology. The above mentioned documents are guiding 7 ecological landscape stratifications from the smallest level, including:

1. Ecological landscape area
2. Eco-landscape type
3. Eco-landscape
4. Ecological region
5. Ecological unit
6. Ecological zone
7. Ecological area.

In reality, it is not necessary to use the 7 cited hierarchy stratification but on the basis of stratification purposes. For instance: Zoning of Vietnamese geomorphology and its neighboring countries by Le Duc An (1985) on map of 1/1.000.000, of which 4 macro geomorphologies were used and called similar to administrative levels as (i) National geomorphology; (ii) Provincial geomorphology; (iii) Regional geomorphology and (iv) Area geomorphology.

Soil association stratified Vietnamese geography-soil (1996) on map of 1/ 1.000.000 also employed 4 macro hierarchy stratifications and called its similar names as stated in Circular no. 193/ UB-VP issued by Economic Zoning Committee in 1963 such as: 2 zones, 6 sub-zones, 16 units and 142 regions.

2.2 Ecological stratification

Ecological stratification is a type of territorial zoning as prescribed in detail under Section 2.1. However, zoning targets at different ecosystems.

2.2.1 Ecological stratification methodology

Ecological stratification has a very important role on identification of physical geography, environmental space, typical ecological rules of each region and sub-regions. **Regional zoning** simply means territorial division into smaller units with similar selected criteria. There are many different regional zoning topologies such as: physical geography, hydro-meteorology, agricultural ecology, forest ecology and water resource ecology.

This overview will synthesize all forest zoning systems and to have basis for selection of forest ecological stratification criteria in Vietnam. It is necessary, first of all to understand some definitions as basis for ecological stratification:

- *Ecological landscape* is the total existing territory with geographic structure and ecological function of an ecosystem that is existing and developing within that landscape.
- *Structure* of ecological landscape comprises landscape structure and ecosystem that are integrated in an entity. An example of a landscape structure: stoneform, topography, soil, organism, hydrology, climate: An example of an ecosystem structure: organic material,

inorganic material, production – consumption and disintegrated organisms.

- *Ecological landscape type* is characterized by a homogeneity on stoneform and other forms in terms of small or medium simple topographical types; sub or local climate; respective hydraulic features; soil units; flora population.
- *Ecological function* is a movement and change of material, energy and shape of the cited structured elements. For example: a mountain, delta, agriculture and forest production models, etc.
- *Ecological region* is a territorial unit with a relative homogeneous structure due to dominant emerging of a geographical architecture under a certain geographical zone; gathering various large topographical shapes which represent all natural elements: climate, hydrology, soil, organism, etc. For example: agriculture, forest, aquaculture production zone.
- *Ecological unit* is established by a geological structured zone that shares development history and forming features. It means gathering large topographical shapes, which are larger than ecological region with common features in terms of climate, hydrology, soil, organisms, etc. For instance: economic region, province, city. etc.
- *Ecological zone* is established in a geographical zone or unit that share the earth's crust structure, which affects climatic zones and its respective vegetations. For instance: equator, temperate, tropical, etc.
- *Ecological area* is the highest hierarchic stratification of continent and ocean scope, which is characterized by territory with various ecological zones. Ecological area often refers to each continent.
- *Ecosystem* is a basic unit of natural landscape. According to Odum, natural landscape structure comprises 4 basic ecosystems: i) Production systems, where its succession is constantly controlled by human being in order to maintain high yields; ii) Conservation or natural systems, where allows or creates favorable conditions for natural succession toward sustainability; iii) Conjugative systems that combine the 2 above systems; and iv) Urban and industrial systems or zones that are not ecologically important.
- There exists the following stratification and zoning types world-wide as follows: (i) ecological stratification for study of ecosystems and natural resources exploitation; (ii) landscape zoning that combines issues related to studies on causes of geographical environment division (N.I.Mikhalov, 1955). As the division of the earth' surface in which the divided region remain territorial integrity and internal unity originated from the most common development, geographical location, geological processes (A.G. Ixatsenko, 1965); (iii) physical geography zoning is unification of territories or hydro-basin, which is rather relative homogenous in terms of a signal that is recognized at a certain level and separates them out of areas without that signal; iv) economic zoning is the division of territory into different economic regions with an aim to identify proper

regional social-economic development direction.

Zoning has the following **features**: (i) territorial integrity (no reiteration); (ii) boundaries identification (identifiable or unidentifiable); and (iii) subjectiveness in zoning reflects zoning purpose following human being's wish.

Zoning has to ensure the following **principles**: (i) relative homogeneity of zoning criteria division; (ii) selection of dominant factors while considering stable evidences of natural ecosystem; (iii) ensuring territorial integrity for harvesting, protection and management.

2.2.2 Ecological stratification work in Vietnam

1) Maize cultivation oriented ecological stratification (Tran An Phong *et al*, 2000). Vietnam inland territory is divided into 3 zones and 9 regions.

2) Central hydraulic ecological stratification (Southern Irrigation Institute, 2008) divided into 4 ecological stratifications as: coastal sand, plains, central hilly and mountainous area.

3) Agro-ecology stratification in Red river delta (Cao Liem, 1990). Among the 3 unfertile, acid and inundated soil types were divided into 8 regions, 13 sub-regions and illustrated on map of scale 1/250.000.

4) Aquacultural production ecology stratification in 8 coastal provinces in Mekong delta on map from 1/250.000 to 1/100.000, etc.

5) "Agro-ecology stratification" has been effectively and widely used.

Territorial division into different agricultural production zones is made on the basis of various ecological conditions as soil, water, and climate. Agro-ecological stratification creates basis for effective agro-resources utilization while strengthening full potential of individual regions aiming to properly select agro-forestry land use type.

Vietnam completed agro-ecological stratification with 7 regions on the entire country's territory: northern mountainous and midland; Red river delta, north central coastal, south coastal, central highland, south east and Mekong delta.

Agro-ecological stratification in Vietnam has provided firm basis for development of provincial master economic zone planning, land use planning in the whole country.

Ecological stratification is closely linked between agriculture and forestry sector and sometimes its results were seen as crucial inputs for forest development planning. There are 7 agro-ecological zones but 8 forestry ecological zones (additional north-west region) and issues that need further study are differences of forest ecosystem emerging and development versus short term food crops system and forest ecosystem itself is supposed to provide environmental protection function. It is, therefore, necessary to select other criteria and hierarchy that are different from those applied in agro-ecological stratification.

2.3 Forest ecological stratification

To date, there has not yet been any work on forest ecological stratification, therefore, 8

forest regions are temporarily used instead of ecological or economic regions. In 2006, when national forest development strategy for 2006-2020 was developed, central region was merged into north-east region as it is not necessary to maintain one centre with similar climate, soil and topographical conditions as those of the nearby region while placing priority on development of more or less 100,000 ha of forest area for Bai Bang paper mill. That is the reason of the 8 forest ecological regions.

Forest ecosystem comprise various forest vegetation types nation-wide and is divided and used according to different methods and purposes which will be specifically prescribed under the coming Section 3.2. To date, no ecological stratification work has been conducted in Vietnam and therefore, the first and foremost concern focuses on scientific basis of “ecological stratification methodology” is described in item 4.

3 Forest vegetation in Vietnam and distribution features

3.1 Introduction on forest and biodiversity resources

3.1.1 Influence factors and natural distribution of forest in Vietnam

Vietnam territory is entirely located within tropical belt with monsoon climate. However, findings of studies on natural climate zoning have indicated that there exist considerable gaps in terms of criteria that affect emergence, development of forest and agricultural ecological systems dominating criteria such as: total annual temperature, daily and yearly amplitude, there is 1 winter season. These criteria also create significant gaps in terms of measurements (diameter, height, tree density, timber volume and biomass), particularly for tropical evergreen mixed forest ecosystem and mangrove forest ecosystem.

While factors as latitude and geographical zone seem not to have obvious effect to forest ecosystem and its bio-productivity, elevation imbalance largely affects establishment of high mountainous temperate ecosystem (sub type according to elevation) as well as its bio-productivity through temperature, precipitation, sunny hours, soil and geomorphology. Item 3 provides detailed description of various forest types. 3/4 of Vietnam territory is hilly mountain, of which vegetation distribution from elevation of 1,000m indicates considerable changes. While several ranges of mountain in the south has elevation of over 2,000 m (Bidup, Chu-yang-sin and Ngoc Linh), mountains in the north are often of the same or even higher elevation (Fangsipang peak of Hoang Lien range is of 3,143 m).

In 1943 when the first forest data area was published, natural forests covered 14.3 million ha (P.Maurant, 1943), mostly being primary forests. After the 2 wars during the period 1945-1954 and 1965-1975, this area went down to 11.2 mil.ha. The sharpest decrease speed was recorded in 1990 after the country unification as forest area was at the lowest level of 9.17 million ha, accounted for 64% of the initial statistics. Since then, thanks to program 327,

661 and reduction of pressure on food and fuel-wood, forest area gradually increased to 11.3 million ha in 2000 and 13.3 million ha in 2009, amounting to around 93% of the initial statistics of forest area. Nevertheless, most of the increased area was plantation forest (3 million ha) while natural forest rehabilitation has been rather slow. Primary ecosystem could only be seen in core zone of protected areas or national parks. Table 1 clearly indicates tendency of forest area change in Vietnam over the last 60 years.

Table 1. Changes of forest area in Vietnam, 1943 - 2009

Year	Forest area, mil.ha			Forest cover %	Ha/capital	Changes versus 1990	
	Natural forest	Plantation Forest	Total			ha	%
1943	14,300	0	14,300	43,0	0,70		
1976	11,077	92	11,169	33,8	0,22		
1980	10,186	422	10,608	32,1	0,19		
1985	9,038	584	9,892	30,0	0,16		
1990	8,430	745	9,175	27,8	0,14		
1995	8,252	1,050	9,302	28,2	0,12		
2000	9,444	1,471	10,915	33,2	0,14		
2005	10,283	2,334	12,617	36,4	0,15	+ 2,432	+15,4
2009	10,339	2,920	13,259	39,1	0,15	+ 4,084	+ 36,4

Source: VNforest, 2010

Similar to the case of total standing tree biomass, timber volume also shared the reduction trend during that period with slower rehabilitation speed. Total timber volume in 1990 was 657 mil. m³, in 2000 : 782 mil. m³ and in 2005: 812 mil. m³

When doing forest ecological stratification, timber volume will be estimated on regional basis. However, it could only reflect volume according to forest status without anticipating potential volume of the rehabilitated ecosystems. Table 2 indicates forest inventory results in 2005 with timber volume of different forest status in the 8 forest ecological regions.

Table 2. Timber volume according to ecological regions (unit: 1000m³)

Item	Nation-wide	North-west	North-east	Red river delta	North central	South Central	Central highland	South east	Mekong delta
Total	811,678	43,030	65,777	4,763	192,321	145,714	288,559	66,005	5,509
Natural forest	758,134	41,320	50,332	3,152	183,274	130,436	285,663	63,186	770

% of natural forest	93.4	96.0	76.5	66.2	95.3	89.5	99.0	95.7	14.0
Plantation forest	53,545	1,710	15,444	1,611	9,048	15,278	2,896	2,819	4,739
% of plantation forest	6.6	4.0	23.5	33.8	4.7	10.5	1.0	4.3	86.0

3.1.2 Forest biodiversity resources

Ecological conditions have a decisive effect on forest ecosystem. Vietnam continental territory stretches from latitude 8°35' north to latitude 23°24' north. It is reaching closer to equator on the south and shares the border line with the sub-tropical belt on the north.

Vietnam has a tropical monsoon climate, with cold and subequatorial winters. Coastline line is of 3,260 km from Mong Cai to Ha Tien, where distributed mangroves, casuarina forest on sand. Hilly terrain account for three quarters of its territory, from the coast to the plains, midlands and highlands, mountainous regions. This topographic conditions has made Vietnam subject to tropical monsoon climate but also subtropical monsoon and high mountainous temperate climate. Excluding Sea climatic zone, continental climate has 3 climatic zones (north, east of Truong Son range, south) with 10 typical climatic regions that represent different ecological region (Pham Ngoc Toan, Phan Tat Dac , 1978). These topographical and climatic conditions have created a lot of the different soil formation processes. Vietnam not only has the typical tropical soils, including soil Feralit, tropical brown and black soil, etc. but also sub-tropical soils, mountainous subtropical soil class and podzoluvisols on high mountain.

The biodiversity of the forests in Vietnam were ranked very high, not only in the region but worldwide. In terms of flora, apart from indigenous and endemic characteristics, Vietnam is the convergence of three plant migration streams from China, India - Himalaya, Malaysia - Indonesia and other regions, including temperate ones

The diversity of plant and animal species is a determining factor in the diversity of natural forest ecosystems of Vietnam (Phung Ngoc Lan, 2006). On the flora, in addition to the elements of indigenous, endemic, Vietnam is the convergence of three streams of plant migration from China, India - Himalaya, Malaysia - Indonesia and other regions, including temperate . According to Nguyen Nghia Thin (2008), Vietnam has around 19,357 plant species, which belong to 2524 **genus and** 378 families, including 1600 fungus, 368 bacterium, 2175 algae, 793 moss, 2 anonymous pineleave, 57 *Pinophyta*, 691 species of ferns, 69 Gymnospermae and 1300 Angiosperms.

Botanists predict the number of plants in our country can be up to 25,000 species. In the above-mentioned species, about 15,000 species of vascular plants, some endemic species of

Vietnam account for about 30% of plants in the north and about 25% of the total number of plants across the country (Le Tran Chan, 1997), at least 1,000 trees reach large size, 354 species of trees can be used for commercial timber production. The bamboo species in Vietnam is very rich, in which at least 40 species have commercial value. The abundance of species has given Vietnam's forests are of tremendous value in economics and science. According to the statics of the Institute of Pharmaceuticals (2003), 3,850 plants has now been discovered and used as herbal treatment, which cured the incurable fatal disease. According to initial statistics, 76 species of myrrh trees, 600 species of trees for tanning, 500 species of trees and 260 species of plant oils to oil have been discovered.

Regarding flora, according to IUCN / CNPPA's data (1986), Vietnam fauna is quite rich in species composition and a high level of endemism than other countries in the regions of Indochina. Of the 21 monkeys in this sub-region, Vietnam has 15 species, including seven endemic species and subspecies (Eudey 1987). According Mackinon, in regions with 49 endemic bird species, Vietnam has 33 species including 10 endemic species of Vietnam. In 2011, Nguyen Nghia Thin have listed the number of animal species in Vietnam with 9,325 species, including 5,500 species of insects, 2476 fish species, 800 birds, 80 amphibians, 180 reptiles and 295 animals.

3.2 Forest ecosystems, scientific basis of classification & application

3.2.1 Definition on forest ecosystem

According to Do Huu Thu (2010), ecology is originated from the Greek word "Oikos" means a habitat, housing, "Logos" is a subject, science. In this sense, it means habitat science.

Ecology has been integrated into many scientists' consciousness and their work since long time. For example in the works of Conrad von Gesner (1555), works of J. Ray (1717), AvHaller (1732), JPde Tournefort (1727) have shown the effects of altitude and latitude to plants distribution. J.G. Gmelin (1750) compared the similarities and differences of the flora of the Siberian with that in European mountains. P.S. Pallas (1741) have shown the dependence of some vegetation on the climate. C.L. Willdenow (1792) pointed out the relationship between plants and environment. He tried to find out the way to divide Europe into different vegetation province, but until 1823 JF Schouw could finally complete this work on division of the world's vegetation into provinces.

The Geobotanik of AF Humboldt (1807), "Ideen zu einer Geographie der Pflanzen" mentioned the relationship between vegetation with environmental factors. The work of J. Liebig (1840, 1843) have shown the relationship between fertilizer and cropping yield. From this work, the author has given the minimum law, one of the fundamental laws of the modern ecology. However the term ecology had just appeared for the first time in 1858 in the letter of the American writer Henry David Thoreau and by 1866, its definition was described in E. Haeckel's book " general morphology of the body. " According to the

author, ecology is general science on the overall relationship between organisms and environment. From 1870, additional authors have further clarified ecology definition.

Besides the definition of E. Haeckel made, the American Scientists Clement F. (1920) also developed other definition: Ecology is the science of relationships. American ecologists H.T. Odum (1959) also offered this definition: Ecology is the science to study on natural structure. Soviet scientists Svartx X's (1972) definition: Ecology is the science of the laws that control the lives of plants and animals in natural habitats.

We face many similar definitions in different research projects. The most common issue of these definitions is the interactions between organisms and their environment. Here we follow the definition of which ecology is a component of the science of life, as science that studies survival and development conditions of organisms, interaction between organism and environment and among organisms during their existence, development and evolution process. Here people are considered biological factors, but the special factors, because it has high social nature that no other creature can get. On the other hand, modern humans have fundamentally changed environment. Thus mankind has been beyond the scope of the original environment concept and stood independently in the natural – mankind system. From this appears human ecology. Mankind is the central object in this ecosystem, all studies has been directed to serve mankind's highest interests. There should also be noted that however advanced human being is, they could not separate from nature. If human being is separated from nature, they will be perished. Nearly 50 years ago, the French scientist wrote "... people have made a huge mistake when announcing that they can be separated from nature and ignoring its rules. Surrounding human and natural environment are intervals. The "old agreement that links the original people with their habitat was canceled by human right after they find themselves strong enough and since then they have only recognized rules and regulations made by themselves. It is important to reconsider thoroughly this view and signed a new agreement with nature – an agreement that bring human ability to live in harmonization with nature" (Quote by V. Dejkin 1985).

In this work, ecology could also be understood as the science of relationships between organisms and environment.

3.2.2 Hierarchy (components) of ecology

From the body level up, the classical ecologists divided ecology into five levels (the 1986 R. Schubert, HJ Mueller 1988) from low to high:

Autecology: term developed by J. Schroeter in 1896.

- Populationecology = Demecology by F. Schwerdtfeger, 1968
- Biogeocenosis = Synecology= community by Schroeter, 1902.

- Ecosystem= Biome
- Biophere.

It is difficult to remember and distinguish Vietnamese as it was compiled from Chinese. It is necessary to remember that community and ecology are frequently used.

The difference between individual ecology and physiology that need to be highlighted are: individual ecology studies the response of the entire organism with the environment, and vice versa, physiological studies response of individual parts of an organism (Duong Huu Thoi, 1998). Obviously, physiology always stick together.

Currently, many authors believe that, there exists only environmental concept but not ecological environment concept. But H.J Mueller (1988) distinguished very clearly environment concept (Umwelt, Environment) and ecological environment (Umwelt Oekologische Umwelt

3.2.3 Main forest ecosystems in Vietnam

Except the mono simple structured forest ecosystem, that occupies small area on the territory such as coniferous forest, mangrove forest, bamboo forest, and plantation forest ecosystem. Majority of tropical forest is mixed forest species, primary or less affected mixed forest species which are very necessary for biological productivity prediction. These ecosystems only distribute in nature reserve areas, national parks, remote and isolated areas, mountainous areas, etc. The following parts describe typical natural ecosystems.

1. *Evergreen closed tropical rain forest*

Forest ecosystems belong to this vegetation is very diversified, abundant and often distributed in provinces as: Quang Ninh, Cao Bang, Lang Son, Phu Tho, Yen Bai, Tuyen Quang, Lao Cai, Ninh Binh (Cuc Phuong), Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, ThuaThien Hue, Quang Nam, Tay Nguyen, etc. Regarding elevation distribution in comparison with sea level, this forest ecosystem is distributed at area of elevation below 700m in the north and less than 1,000 m in the south.

This forest ecosystem has storey oriented structure with 5 storeys:

- Upper storey A_1 : wood trees with height up to 40 - 50 m, belonging to Dipterocarpaceae, Moraceae, Leguminosae, etc.
- Ecological dominance storey A_2 : Majority is evergreen species belonging to Fagaceae, Lauraceae, Caesalpiniaceae, Mimosaceae, Papilionaceae, Sapindaceae, Meliaceae, Magnoliaceae and Burseraceae, etc.
- Lower storey A_3 : with height from 8 - 15 m, grew scatteredly under forest canopy and belonging to Clusiaceae, Ulmaceae, Myristicaceae, Annonaceae, Flacourtiaceae, v.v.
- Bushes storey B: with height from 2 - 8 m, belonging to Rubiaceae, Apocynaceae,

Rutaceae, Annonaceae, Melastomaceae, Araliaceae, Euphorbiaceae, etc.

- Climber storey C: with height less than 2m and belonging to Acanthaceae, Urticaceae, Araceae, Zingiberaceae, Liliaceae and various fern species, etc.

Vegetation subzones including in this forest ecosystem are as follows:

- Flora of Sothern Vietnam – Malaysia and Indonesia with Dipterocarpaceae dominance:

Recognizable typical features of this subtype is dominance of Dipterocarpaceae in upper storey. Majority of forest trees are evergreen species as *Hopea odorata*, *Hopea pierrei*, *Hopea ferrea*, *Hopea mollissima*, *Vatica tonkinensis*, *Vatica fleuryana*, *Parashorea stallata*, etc. In the south, particularly in Central highland, typical species are *Dipterocarpus alatus* and *Dipterocarpus turberculatus*.

Apart from Dipterocarpaceae, there are other evergreen species as *Sindora*, *Ormosia*, *Cassia*, etc; belonging to Leguminosae family as *Lithocarpus*, *Castanopsis*, *Quercus*, etc., belonging to Fagaceae family as *Syzygium*, *Eugenia*; Myrtaceae family as *Camellia*, *Terstoemia*, *Schima*; Theaceae family as *Garcinia*, *Mesua*, *Calophyllum*; Clusiaceae family as *Dracotomelum*, *Bouea*, etc.; Anacardiaceae family as *Aglaia*, *Aphanamixis*, *Dysoxylon*, *Chisocheton*; and Meliaceae family.

Key dominant groups comprise: *Hopea odorata*; *Hopea pierrei*; *Parashorea chinensis*; *Dipterocarpus tonkinensis*; *Dipterocarpus alatus*; *Vatica* sp.; *Anisoptera costata*.

- Flora of Northern Vietnam – South of China: This subzone is often distributed in low land, in northern part with elevation of less than 700 m above sea level and on Isotherm during the coldest months of 20°C; in the south, it is distriuted in low humid area of less than 1,000m above sea level and in Truong Son mountain range..

Main dominant groups include: *Lauraceae*; *Fagaceae*; *Meliaceae*; *Moraceae*; *Magnoliaceae*; *Leguminosae*; *Anacardiaceae*; *Burseraceae*; *Sapindaceae*; *Sapotaceae*, etc..

2. Semi-deciduous closed tropical humid forest

This forest ecosystem is distributed in Quảng Ninh, Bắc Giang, Bắc Kạn, Tuyên Quang, Phú Thọ, Yên Bái, Sơn La, Lai Châu, Thanh Hoá, Nghệ An, Tây Nguyên and south-east region, etc. In comparison with elevation above sea level, this forest ecosystem is often distributed at the elevation of less than 700 m in the north and less than 1,000 m in the south.

Forest composition comprises timber trees (A1, A2 and A3) with two typical deciduous species as *Lagerstroemia tomentosa* and *Liquidambar formosana*. In addition, there exists as well other species as Dipterocarpaceae, Meliaceae, Leguminosae, Datisceae, Moraceae, Anacardiaceae, Combretaceae, Lauraceae, Burseraceae, Sapindaceae, etc. Population height reach 40m with numbers of species **with buttress roots**. Various subzones are as follows:

- Flora sub-zone that is close to flora of Malaysia-Indonesia and flora of India-Myanma: This subzone was recorded in Muong Xen, Con Cuong (Nghe An), with typical species of *Lagerstroemia tomentosa*, which grows in the mixture with *Erythrophoeum fordii*, *Peltophorum tonkinensis*, *Madhuca pasquieri*. In addition, there are number of other deciduous species as *Quercus acutissima*, *Quercus serrata*, *Quercus griffithii*, *Styrax tonkinensis*, *Melia azedarach*, *Peltophorum tonkinensis*. There exists as well population of mono deciduous species as *Lagerstroemia tomentosa* in Con Cuông (Nghệ An), *Liquidamba formosana* in Huu Lung (Lang Son) and Bien Dong (Bac Giang). Vietnam flora comprises various deciduous speices belong to different families such as Dipterocarpaceae, Leguminosae, Combretaceae, Datisceae, Sterculiaceae, Anacardiaceae, Xoan (Meliaceae), Nhãn Sapindaceae, Bignoniaceae, Ulmaceae, Moraceae, Verbenaceae.
- Flora subzone that is close to indigenous flora of north Vietnam – south China and migrating flora of India - Myanma: This subzone comprises deciduous species belonging to different families as Meliaceae, Sapindaceae, Leguminosae, Anacardiaceae, Burseraceae, Verbenaceae.

3. Evergreen broad leaved forests on limestone

Limestones could be found in 24 provinces and cities but mainly distributed in north and north-central region. Provinces with limestones are Điện Biên, Lai Châu, Sơn La, Hòa Bình, Hà Giang, Cao Bằng, Lạng Sơn, Quảng Ninh, Hải Phòng, Ninh Bình, Thanh Hóa, Thái Nguyên, Nghệ An, Hà Tĩnh, Quảng Bình. It is possible to divide limestones into the following 5 zones: Cao Bằng - Lạng Sơn; Tuyên Quang - Hà Giang; Tây Bắc - Tây Hòa Bình - Thanh Hóa; North Trường Sơn and islands.

By latitude, this forest ecosystem stretches from Hà Tiên to Cao Bằng ((23°B) on ward. By elevation, this ecosystem distributed at the elevation from several tens of meters to 1,200m above sea level. It has storey oriented structure with rather abundant species composition. It is possible to divide this forest ecosystem according to the following elevations:

3.1. Forests on limestone below 700m

a) Evergreen closed forest on foot of limestone: complex forest structure with 5 storeys:

- Upper storey (A_1): Tree height of over 40 m belonging different families as Leguminosae or Combretaceae, Dipterocarpaceae in addition to some common species as: *Dracontomelum duperreanum*, *Tetrameles nudiflora*, *Pometia pinnata*, *Anogeissus acuminata*.
- Ecological dominant storey (A_2): including trees with from 20 - 30m height and belonging to different families as: Fagaceae, Lauraceae, Caesalpiniaceae, Mimosaceae, Fabaceae, Sapindaceae, Magnoliaceae, Meliaceae and various *Hopea siamensis*, *Knema* sp and *Hopea* sp.
- Lower storey (A_3): including trees below 15m hight and grow scateredly and belong

to various families as Clusiaceae, Ulmaceae, Annonaceae with many genus: *Hydnocarpus* sp., *Sterculia* sp., *Pterospermum* sp., *Baccaurea ramiflora* and typical species as *Streblus ilicifolius*, *Streblus macrophyllus*, etc.

- Bushes storey (B): including bushes, small trees below 8m height belonging to various families as Apocynaceae, Rubiaceae, Melastomataceae, Araliaceae, Euphorbiaceae and Acanthaceae, etc.
- Fresh vegetation storey (C): including low plant below 2 m and belonging various families as Araceae, Acanthaceae, Urticaceae, Zingiberaceae, Begoniaceae, Convallariaceae, v.v. Other plants include liana of different families Vitaceae, Fabaceae, Connaraceae in addition to medlar-trees and parasitic plants of different families as Orchidaceae, Loranthaceae and Araceae, etc.

b) Evergreen forests on limestone slopes:

Evergreen forest species in limestone includes *Streblus ilicifolius*, *Streblus macrophyllus*, *Clausena lansium*, *Walsura* sp., *Arytera* sp., *Celtis* sp., *Garcinia fagraeoides*, *Phoebe* sp., *Chukrasia tabularis*, *Drypetes perreticulata*, *Alphonsea* sp., *Miliusa balansae*, *Glycosmis* sp., *Diospyros* sp., *Arenga pinnata*, *Knema* sp., *Cleistanthus sumatranus*, *Polyalthia* sp., *Vitex* sp., *Aglaia gigantea*, *Spondias lakonensis*, etc.

c) Evergreen forests on top of limestones

Simple forest structure with 1-2 storey comprising trees from 8-15 m height as *Schefflera* spp., *Memecylon* spp., *Sinosideroxylon* sp., *Boniodendron* sp., *Pistasia cucphuongensis*, *Mallotus philippensis*. Low storey plants are bushes as *Melastoma* spp., *Syzygium* spp. and fresh vegetation as *Dryopteris* spp., *Colysis cucphuongensis*, *Tectaria* spp., *Selaginella* spp., *Alpinia* spp., *Begonia* spp., *Impatiens* spp., *Kalanchoe* sp. In comparison with other species belonging to families of Orchidaceae, *Loranthus* spp., *Jasminum* sp., *Coccinia grandis*, *Hodgsonia macrocarpa*, etc.

3.2. Forests on limestones with elevation of 700 – 1000m

Limestones area is at elevation of over 700m, mainly distributed in the north, particularly north-east, including Cao Bang, Ha Giang, Lang Son, etc. Besides, there exists some scattered limestones in north-central region along Viet-Lao border as: Pu Xai, Lai Leng, Pù Hoat, Pu Huong, Xuan Lien. Main forest types include:

a) Evergreen broad leaved forests on valley and foots of limestone:

Common species include *Aglaia* sp., *Dipterocarpus retusus*, *Shorea chinensis*, *Vatica diospyroides*, *Quercus* spp., *Lithocarpus* spp., *Michelia* sp., *Manglietia* sp. and *Litsea* spp., *Cryptocarya* spp., *Machilus* spp. In 1st storey, there are *Diospyros* spp., *Engelhardtia* sp., *Bischofia javanica*, *Cipadessa baccifera*, *Hydnocarpus clemensorum*, *Pterospermum* sp., *Celtis cinamomea*, *Eriobotrya poilanei*, *Cinnamomum bonii*, *Toona sinensis*, *Koelreuteria* sp. In 2nd story, there are *Diospyros* spp., *Gironniera subaequalis*, *Polyalthia* sp., *Clausena*

spp.

b) Evergreen broad leaved limestone forest:

Common species are *Burretiodendron*, with diameter from 70 - 80 cm, *Garcinia* sp., *Marchantia* sp., *Pterospermum heterophyllum*, *Syzygium* spp, *Diospyros* sp., *Phoebe* sp, *Polyalthia* sp, *Alangium chinense*.

c) Mixed broad and needle leaved forests on top of limestone

Common species are *Ficus* sp., *Syzygium* spp, *Schefflera octophylla*, *Juglans* sp., *Ulmus* sp., *Pittosporum* sp., *Schefflera halongensis*. Apart from the above mentioned broad leaves as *Cycas* spp., *Cupressus torulosa*, *Dacrydium elatum*, *Nageia fleuryi*, *Podocarpus pilgeri*, *Pinus kwangtungensis*, *Keteleeria davidiana* var. *davaniana*, *Amentotaxus hatuyenensis*, *Amentotaxus yunnanensis*, *Taxus chinensis*, *Pseudotsuga chinensis*, *Xanthocyparis vietnamensis*. Common species in low storey are *Pistacia weimanifolia*, *Calophyllum bonii*, *Clausena indica*, *Dracaena cambodiana*, *Laportea* sp., *Begonia* sp., *Mahonia nepalensis*, *Setaria palmifolia*, etc.

d) Short broad leaved forest on top of limestone

One storey forest composition with small timber trees of 6-10 m height. Typical species are as follows *Cycas* spp., *Pseudotsuga chinensis*, *P. brevifolia*, *Tsuga chinensis*, *Illicium griffithii*, *Schefflera* spp, *Quercus* spp., *Lithocarpus* spp., *Ternstroemia japonica*, *Pistacia weimanifolia*, Ericaceae as: *Rhododendron* spp., *Vaccinium dunalianum* and *Cinnamomum* sp., *Jasminum lanceolarium*, *Tirpitzia sinensis*, etc.

4. Natural needle leaved forests

Needle leaved forest ecosystem comprises 2 types: lowland sub-tropical needle leaved forest, which mainly distribute in mountainous areas as Yen Chau, Moc Chau (Son La), Nghe An, Ha Giang, Da Lat (Lam Dong), etc and temperate highland needle leaved forest mainly distribute in Sa Pa (Lao Cai), Tuan Giao (Lai Chau) Ha Giang, Tay Con Linh (Cao Bang), Chu Yang Sinh (Nam Trung bo), Lam Dong, etc. Natural needle leaved forest ecosystems include:

a) Lowland sub-tropical needle leaved forest

In the south, main timber species are *Pinus merkusii*, *Pinus kesiya* that grow alternatively with *Dipterocarpus obtusifolius*. In the north, typical species are *Keteleeria davidiana*, *Pinus merkusii*. There are 2 subtypes of this ecosystem:

- *Subzone that is close to India – Myanma flora*: in the south, typical species are natural *Pinus merkusii* growing alternatively with *Dipterocarpus obtusifolius*, *Lithocarpus harmandii*, *Michelia bailonii*, etc. Low bushes include species as *Vaccinium chevalierri* and *Schima crenata* meanwhile fresh vegetation comprise *Dicranopteris linearis*, *Nephrolepis hirsuta*, etc.
- In the north, there are some species as *Erythrophoeum fordii* Olive, *Castanopsis*

tribuloides, Re (*Cinnamomun* sp) in Quảng Yên (Quảng Ninh). Bushes include *Vaccinium chevalierri*, *Wendlandtis glabrata*.

- Subzone that is close to Himalaya - Vân Nam - Quý Châu flora: with typical species as *Pinus kesiya* that grow alternatively with *Quercus helferiana*, *Lithocarpus dealbata*, *Lithocarpus pynostachya*, etc. Besides, there are also some species of Ericaceae family.

In high mountainous area of Moc Chau (Son La), Thuan Chau (Lai Chau), etc, there are *Keteleeria davidiana* which is dominant on upper storey together with some species as *Quercus griffithii*, *Quercus serrata*, *Quercus acutissima* and other species of Lauraceae family.

b) Temperate needle leaved forests on medium mountain:

Within this belt, there exists mono species needle leaved forest as *Fokienia hodginsii*, *Cunninghamia lanceolata*, *Podocarpus imbricatus*. In alternative with *Fokienia hodginsii*, there are also *Ducampopimus krempfii*, *Pinus dalatnensis*. Besides, in high mountainous tropical belt belonging to Panxipang mountain – at the elevation from 2,400 – 2,900 m and over 2,600 m, there exist *Tsuga yunnanensis* and *Abies pindrow* respectively.

Sub-type of this ecosystem is the flora subzone that is close to the North Vietnam-South China flora. This subtype is found in Muong Phang at the height of 1,335 m above sea level with 3 dominant storey as *alocedrus macrolepis* at the height up to 35m, grow alternatively with *Actinodaphne sinensis*, *Phoebe* sp, *Litsea baviensis* etc. belonging to Lauraceae family and *Castanopsis hickelii* belonging to Fagaceae family. Storey A₂ is at the height from 10 - 20 m, including some species of Lauraceae, Sapindaceae, Myristicaceae and Ulmaceae family. Storey B comprises some species as *Blastus* sp, *Pinanga baviensis*), *Lasianthus* sp, *Gymnosphaera podophylla* and *Arundinaria* sp.

5. Dry dipterocarp forest

Dipterocarp forest distribution concentrated in the provinces of Dak Lak, Gia Lai. There is also at Di Linh (Lam Dong) and small clusters distributed dipterocarp forest in Ninh Thuan, Binh Thuan, Song Be, Tay Ninh. Regarding latitude, dipterocarp forest distributed from latitude 14°B (Gia Lai) to latitude 11° North (Tay Ninh). Dry dipterocarp forest distributes intensively at the height from 400 to 800m above sea level. Dipterocarp forest flora associated flora Malaysia - Indonesia with dominant species of Dipterocarpaceae family of 204 genus, 68 families, of which over 90 timber species with 54 large and medium timber species.

Other dominant dipterocarpus species include: *Xylia xylocarpa* of Mimosaceae family, *Dilleniahe terosepala* of Dilleniaceae family, *Vitex pendencularia* of Verbenaceae family, *Buchanania arborescens* of Anacardiaceae family, etc. On good site conditions, there exist as well some valuable species as *Pterocarpus macrocarpus*, *Dalbergia bariensis*, etc. The following part introduces 4 popular *Dipterocarpus* dominance.

- *Shorea siamensis* dominance: *Shorea siamensis* grow in mixture with other 2 common species as *Dipterocarpus tuberculatus* and *Pterocarpus macrocarpus*. In addition, there exist as well other species as *Shorea obtusa*, *Nauclea* spp., *Lagestroemia* spp., etc.
- *Shorea obtuse* dominance: *Shorea obtuse* account 50% of the entire population. Besides, it also grows in mixture with *Shorea siamensis* and *Dipterocarpus obtusifolius*, etc.
- *Dipterocarpus tuberculatus* dominance: 3 common species grow alternatively with *Dipterocarpus tuberculatus* are *Shorea siamensis*, *Shorea obtusa*, of which *Dipterocarpus tuberculatus* and *Shorea siamensis* largely contribute to forest volume.
- *Dipterocarpus obtusifolius* dominance: This dominance distributes intensively on areas from 600 - 900 m above sea level in Dak Lak, Gia Lai and Lam Dong provinces

6. Mangrove forests

Mangrove forest ecosystem distribute along Vietnam coastal line in 28 provinces and cities. Phan Nguyên Hồng (1999) divided mangrove forest in Vietnam into 4 zones with 12 subzones and at the same time identified ecological conditions for each zone: zone I – north east coastal; zone II – northern coastal; zone III – coastal area in central region from Lach Truong cape to Vung Tau cape; zone IV – coastal area from Vũng Tàu to Nãi, Hà Tiên cape (eastern coastal of Ca Mau peninsula).

This ecosystem represents salt demanding species as *Rhizophora apiculata*, *R. Mucronata*, *Brugyeria parviflora*, *B. Gymnorhiza*, *Kandelia ovata* that are belonging to Rhizophoraceae family; *Avicennia marina*, *A. Alba*, *A. Oficinalis* of Avicenniaceae family; *Sonneratia alba*, *S. Caseolaris* of Sonneratiaceae family; *Phoenix paludosa* of Palmae family.

7. *Melaleuca cajuputi*

This ecosystem distributes in 7 Mekong delta provinces, forming the following 3 region: i) Thap Muoi delta stretches over territory of the 3 provinces: Long An, Tien Giang and Dong Thap; ii) Long Xuyen quadrangular that shares territory of An Giang and Kien Giang province; and iii) U Minh Thuong, U Minh Ha in Ca Mau and Kien Giang province.

Previously, scientific name of *Melaleuca* was defined as *Melaleuca eucodendron*. In 1993, this scientific name was redefined as *Melaleuca cajuputi* (Scott Poynton, 1993). *Melaleuca* species in Vietnam has at least 4 varieties as *Malaleuca* population and communities that distribute naturally on acid soil in Mekong delta meanwhile some *Malaleuca* population distribute naturally in Quang Binh, Quang Tri and Thua Thien Hue. As *Melaleuca* forest ecosystem established under typical alum inundated environment, only some species could adapt and survive to this habitat. As the results, forest composition is much simple in comparison with evergreen mixed forest ecosystem.

8. Bamboo forest

Bamboo and rattan is common name for all plants of Bambusoideae, Gramineae or Poaceae. Bamboo and rattan widely distribute from tropical, sub-tropical to temperate, from latitude 51° north to 47° south. Worldwide, there are about 1,3000 species of over 70 genus, distributed in 3 main regions: Asia Pacific, Americas and Africa, of which the Asia Pacific region is seen as the bamboo distribution centre, which accounts to 80% of the total species and area worldwide. (Lin, 2000).

Vietnam is one of the bamboo distribution worldwide. There are 133 species of 24 genus. Bamboo and rattan ecosystem in Vietnam comprises the following ecosystem:

- *Dendrocalamus barbatus*

Scientific name is *Dendrocalamus barbatus* Hsueh et Li. Previously, it was called *Dendrocalamus membranaceus*. *Dendrocalamus barbatus* is widely distributed in many provinces as Thanh Hoá, Nghệ An, Hà Tĩnh, Sơn La, v.v, and mostly focused in Thanh Hoá. Natural *Dendrocalamus barbatus* is found along Ma river, Sơn La province and the remaining area is plantation *Dendrocalamus membranaceus*.

- *Acidosasa* and *Indosasa*

Acidosasa and *Indosasa* is common name for some scattered bamboo species belonging to *Acidosasa* and *Indosasa* genus, including some main species as: *Indosasa* sp., *Indosasa amabilis*, *Acidosasa* sp., *Acidosasa* sp., etc. Among all the *Acidosasa* và *Indosasa* in our country, *Acidosasa* sp has the most significant meaning thanks to large and intensive distribution area with high dimension and economic value. As such, this part will introduce on *Acidosasa* and *Indosasa*. *Acidosasa* and *Indosasa* distribute largely in some provinces as Lào Cai, Yên Bái, Hà Giang, Tuyên Quang, Bắc Kạn, Phú Thọ, Thái Nguyên, Lạng Sơn, Quảng Ninh, Sơn La, Hòa Bình, Thanh Hóa, etc.

- *Neohouzeaua forest*

Neohouzeaua is a common name for some group growing species that belong to *Schizostachyum* genus. Previously, it was included in *Neohouzeaua* genus, of which *Schizostachyum funghomii* and *Schizostachyum pseudolima* have high economic value and distribute largely all over the country. *Schizostachyum pseudolima* distributes largely in the whole country but intensively focus in the central north and north central region.

- *Bambusa balcoa*

Bambusa balcoa has many different names and currently, it could be called *Bambusa balcoa* Roxb. *Bambusa balcoa* distributes largely in south-central, central highland and south east region and mostly focuses in south east region, particularly Bình Phước province.

3.3 Forest classification systems

Over the last half century, on the basis of different scientific foundation and utilization objectives, Vietnam's forests have been classified according to various methodologies leading to diversified results, which have been applied in forest business, planning and management in the whole country. Theoretical basis and methodology are seen as reference sources for research and teaching at different levels.

The classification system based on ecosystem with five main factors governing emerging, development of tropical forests in Vietnam reached an echo during the '60s, but the 14 forest types – apart from its theoretical value, have not been significantly applied. While the German system that was transferred into Vietnam by late 50th decade, which divides forest status classification into 4 types without any methodology, it was widely and constantly used thanks to its simplicity, practicality that is in close connection with timber volume calculation. To date, this system has been improved from time to time. Within this report, the 5 main forest classification is presented.

3.3.1 Forest classification system according to forest statuses

In 1959, the forest classification system of Germany with 4 forest types was transferred by Loeschau to Vietnam:

Type IV: Primary or less intervened forest, including natural ecosystems with its structure seen as product of emerging ecological factors, with volume, productivity and various natural forest products without following the economy' selecting direction. Forest type IV, including IVA and IVB indicates primary forest and mature plantation forest

Type III: Natural forests has been intervened in different extents, so it is in the division (or being recovered, or degraded). Depending on the intervention extent, whether it is high or low, forest of type III is divided into 3 levels:

- IIIa: High intervention extent, forest is degraded and seriously impact its normal storey structure, its productivity and volume is critically degraded at various levels (IIIa1), the 2nd type is seriously impacted but still remains natural rehabilitation capacity (IIIa2). Subsequently, additional type of IIIa3 and IIIa2 were further regulated in production.
- IIIb: Medium intervention extent is usually seen as mature forest harvest (type IV), or rehabilitated forest after harvest (type IIIa) that follow promulgated regulations so as to meet harvesting intensity requirements in terms of structure and productivity.
- IIIc: This type indicates low and minor intervention of human being in forest of type IV or fully rehabilitated forest of type III. Forest type IIIc is less common and rarely classified in comparison with type IIIa and IIIb.

Type II: Young forest, including:

- IIa - natural rehabilitated young forest after deforestation or burned or due to slopping cultivation.

- IIb - young forest/man-made forest with closed canopy and inconsiderable timber volume.

Type I: Barren land, denuded hills that have never been forest or deforestation due to over exploitation, forest fire or other causes. However, excluding white sandy beach, there exist grass, bushes and regenerated trees from seeds or buds as high as bushes or grass on barren land and denuded hills. In reality, FIPI has added 3 sub-types which are widely used to date:

- Ia: Barren land: grass or scattered bushes with cover below 30%.
- Ib: Barren land covered by vegetation or bushes or mixture of both with cover of more than 30%.
- Ic: Barren land and denuded hills of Ib type with various regenerated young trees. Ic type has just been newly regulated in the 327 program (1992-1997) with guidance on maintenance, rehabilitation or natural regeneration where there exist potentials that regenerated trees could become natural forest of IIa type.

This classification system has been widely employed in forest production from mid of the XX century to date and has been gradually supplemented, completed to meet the sector development requirements. The latest supplementary was the redefinition of forest in accordance with Circular no. 34/2009/BNN in 2009. However, this classification only aims to serve forest classification according to the existing volume for forest business, timber harvesting rather than following ecological, emerging, development basis or species composition of forest vegetation.

3.3.2 Forest vegetation classification according to emerged ecological factors

On the basis of the “biogeocoecology” theory of the Academician V.N. Sucasov (1957) and the ecosystem of A.G. Tansley (1930), Thái Văn Trùng (1963, 1999) followed the flora population emerging ecology viewpoint to classify forest vegetation in Vietnam. Academic ideology of this viewpoint reflects that in a particular ecological environment, there exists only a certain native vegetation type. In such an ecological environment, there are five groups of ecological factors emerge to influence decisions of forest species composition, structure and form of respective vegetation types. Based on this logical basis, Thai Van Trung used five factors (climate, topography, soil, vegetation, human’s intervention) to classify forest vegetation of Vietnam into 14 forest types on forest land as follows

Lowland closed forests

- I. *Evergreen closed tropical humid forest*
- II. *Semi-deciduous closed tropical humid forest*
- III. *Deciduous closed tropical low humid forest*
- IV. *Closed, hard leaved, low humid forest*

Sparse forests

- V. Thin broad leaved, tropical low humid forest
- VI. Thin needle leaved, tropical low dry forest
- VII. Thin, needle leaved semi-tropical, low dry forest on low mountain

Sannava

- VIII. Tropical dry big trees, bushes, grass sannava
- IX. Tropical dry bushes sannava

Highland closed forests

- X. Evergreen closed sub-tropical rainy forest on low mountain
- XI. Mixed, closed, broad and needle leaved subtropical rainy forest on low mountain
- XII. Closed needle leaved, humid, temperate forest on medium mountain

Dry, cold ecosystems on high areas.

- XIII. Dry ecosystem on high areas
- XIV. Cold ecosystem on high areas

Each vegetation zone is divided into subzones (depending on plant composition), sub-soils (depending on soil conditions), sub-human's factors (depending on impacts of human's intervention) and it is up to species advantages that form different natural complex, dominance and communities. As such, forest ecosystem picture in Vietnam is very diversified according to Thai Van Trung's classification system.

3.3.3 Forest classification according to elevation belt and ecological conditions

Trần Ngũ Phương (1970) proposed forest classification in the north of Vietnam following soil, climate, elevation and typical factors of forest to classify forests in the north into 3 forest belts. Each forest belt comprises one or some fundamental forest types:

A. Seasonal rainy tropical forest belt:

- Mangrove evergreen broad leaved tropical forest
- Evergreen broad leaved seasonal rainy tropical forest
- Evergreen broad leaved tropical rain forest
- Vally broad leaved tropical forest
- Limestone evergreen broad leaved tropical forest

B. Seasonal rainy sub-tropical forest belt:

- Evergreen broad leaved sub-tropical forest
- Limestone needle leaved sub-tropical forest
- Earth mountain needle leaved sub-tropical forest

C. Highland seasonal rainy sub-tropical forest belt

- This belt comprises 3 types that are *Fokienia hodginsii*, *Cunninghamia lanceolata* and *Rhododendron simsii*.

This ecosystem classification is seen as initial results of study on forest silviculture in northern part of Vietnam, which was reported at the Forestry Conference held in Bac Kinh in 1967, published in 1970.

3.3.4 UNESCO's forest classification system

UNESCO (1973) classified forest vegetation into 4 ecosystems. In Vietnam, there are 4 layers: thick and thin ecosystem.

Each ecosystem layer is divided into sub layer, which is further divided into ecosystem group and finally comes ecosystem itself. Individual ecosystem is divided into sub-ecosystem which is followed by a population. Base on the above mentioned classification principles, forest vegetation in Vietnam is classified in a rather complicated way as follows:

I. Closed forest ecosystem comprises 3 main sub-types: evergreen forest, deciduous forest and dry forest.

1. Tropical evergreen forest ecosystem classification:

a) Evergreen rainy forest ecosystem group

b) Evergreen seasonal rainy forest ecosystem:

- Lowland forest
- Low mountain forest
- Medium mountain forest
- High mountain forest
- Low limestone forest
- Medium limestone forest
- Coastal sandy forest
- Forest on sediment
- Swamp forests
- Mangrove forests
- Low mountain pine forest
- Low mountain bamboo-rattan forest

c) Tropical semi-deciduous forest ecosystem group:

- Lowland tropical semi-deciduous forest
- Tropical semi-deciduous forest on low mountain

- Tropical semi-deciduous forest on limestone
- Tropical semi-deciduous forest on medium mountain

2. *Tropical deciduous forest ecosystem classification*

- Tropical deciduous forest
- 3. Tropical dry forest ecosystem classification

a) Dry hard leaved forest ecosystem group

b) Thorn forest population:

- Semi-deciduous thorn forest
- Deciduous thorn forest

II. Ecosystem: Sparse forests

This ecosystem comprises 3 sub-ecosystems:

1. *Evergreen thin forest sub-ecosystem:*

a) Broad leaved thin forest ecosystem group:

- Forest on low land
- Forest on low mountain

b) Needle leaved forest ecosystem group

2. *Classification of broad leaved deciduous forest on mountain and low land*

3. *Classification of dry thin forest ecosystem:*

a) Dry hard leaved forest ecosystem group

b) Thin thorn forest population:

- Semi deciduous thorn forest
- Evergreen thorn forest

Forest vegetation classification of Thai Van Trung, Tran Ngu Phuong and UNESCO affirmed diversity of forest ecosystem in Vietnam with 5 ecological factors. However, these works remain as theory and has not widely been applied, yet only partial application in production practices if any.

3.3.5 Forest classification according to the Forest Sector Manual

On the basis of the 5 above mentioned ecological factors, Phung Ngoc Lan and colleagues (2006) re-systematized, re-arranged into 8 main ecological systems with respective internal structure of each type. Individual system is seen as a main forest type. Each forest type also comprises sub-zone and dominance of site indicated species. Each ecological system is well described in terms of distribution, ecology and structure. Natural forest ecosystems are as follows:

- Evergreen closed tropical rain forest

- Semi-deciduous closed tropical rain forest
- Evergreen broad leaved forests on limestone
- Natural needle leaved forest
- Thin dipterocarpus forest
- Mangrove forest
- Malaleuca forest
- Bamboo- rattan forest

To certain extent, natural ecosystem classification is similar to current status classification with detailed explanation on internal structure characteristics of forest and its development circumstance.

3.3.6 Forest types used in forest ecological stratification

Primary forest ecosystems are important evidences to demonstrate the established ecological conditions while ensuring their long term existence on different territorial areas of Vietnam. However, during historical development process, ecological factors also changed either slowly or suddenly, particularly anthropogenic factor that have left us a diversified but very complex patch with too many forest types dominated by secondary or plantation forest which is briefly presented above including methodology, use efficiency of each systems so as to have adequate basis for selection of main forest type (in equivalence with ecosystem) within each territorial zone.

Among the 10 selected forest types, it comprises all types of natural successive primary of forest classification according to Forest Sector Manual while supplementing all secondary forests under successive process, plantation forest, different vegetations (savanna according to Thái văn Trung, 1963; Ib, Ic classification according to supplementary status classification) to cover all forest vegetation types.

Table 3 list 10 main forest types and respective code of each forest type with 4 sub-types of mixed natural forest.

Table 3. Main forest types in Vietnam

Code	Forest type
I	Closed, mixed evergreen broad leaved rain forest; sub-types: 11: low land, < 700 m in the north, < 1000 m in the south 12: low land in the south, Dipterocarp dominance 13: hill (<300m), low mountain (700 – 1500m) in the north; low mountain (500 – 1000m); medium mountain (1000 – 2000m) in the south (according to Forest Sector Manual) 14: high mountain > 1500m in the north, >2000m in the south

II	Semi deciduous mixed forest
III	Mixed lime stone forest
IV	Coniferous forest, mixed coniferous and broad leaved forest
VI	Sparse forest, seasonal deciduous forest, dipterocarp dominant forest
VII	Mangrove forest
VIII	Forest on alum land (Melaleuca forest)
IX	Bamboo forest and mixed timber and bamboo forest
X	Plantation forest of all types

4 Scientific basis of hierarchic stratification criteria

Theoretically, the most important criteria for forest ecological stratification is the existence of ecosystems (or that forest type) on stratified unit. Therefore, if there exists primary ecosystem, whose peak could be called ***climax***, then ecological factors are referential theoretical systems that generate environment for establishment of that ecosystem. However, majority of cases are at low hierarchical stratification level of *sub-region*. When the primary ecosystem does not any longer exist, it is necessary to have a criteria for establishment and development of that ecosystem following the principle that a certain ecosystem context creates its respective forest type. This would become the basis for demonstrating that such a primary ecosystem used to exist there, or the current successional conditions of the existing forest types has followed the rehabilitation tendency of that primary ecosystem.

Within the scope of a forest ecology research, while considering 5 emerging ecological factors, the 5th factor “human being factor” shall be considered as human induced effects, including both friendly or destroyable to nature. “Flora” factor is seen as practical truth that identifies appropriateness of natural distribution of primary forest types, which are now replaced by intermediate or being degraded or being rehabilitated forest types and should be considered objective practical targets of the stratification theory.

The 3 remaining ecological criteria, shortly called “climate”, “topography” and “soil” are the 3 most important criteria determining the forest types, which were stratified. However, within each hierarchy and for specific cases, exceptional driving or less influential factors will be identified from research findings or by experts’ experiences. For instance: obviously distinguished climate criteria and its influence levels on large hierarchy scope as zone, region meanwhile soil related criteria seem to have obvious influence on smaller hierarchy as region, sub-region or smaller units.

These 3 are independent specialized factors, that were studied and zoned on Vietnam’s territory or zoned in correspondence to other various economic sectors (detailed description in item 2.1) on territorial zoning or in climate factors. Apart from natural climate zoning, there is also climate zoning applicable to agriculture and construction sector – as described under **Section 4.1** hereafter. As such, in comparison with forest ecological stratification,

these specialized sectors have made considerable progress. Hereunder, are summarized key territorial zoning achievements of individual sectors.

For linkage among ecological factors for establishment and development of ecosystems, each factor recommended criteria and indicator (C&I) to the forestry sector for selection as well as suggestions for each hierarchy when doing forest ecological stratification.

4.1 Hydro-meteorology

4.1.1 International experiences

World-wide, there are many appropriate systems and methodologies that could be employed under different conditions. The following systems have been employed for climatic classification:

- Koppen's classification system (1918-1936): a combination of temperature and precipitation factors are adopted. Subsequently, additional complementary factors were added by Trewartha to make a Koppen-Trewartha system, which creates world climate classification comprising 7 groups from A to H, from extremely hot to extremely cold regions that is illustrated through indicator "number of months with average temperature over 18⁰C", or for group C with indicator as of average temperature of over 10⁰ C.
- Thornthwaite's classification system: This is Koppen's system in combination with measurement of water evaporation in an area. It also uses humidity and aridity related indicators for the humidity volume for vegetation.
- Holdridge's classification system, 1947, 1967: This is a world-wide climate based system on land classification and mapping. This system is accumulated from 3 indicators: temperature, latitude and elevation belt.
- FAO's ecological stratification principles (Zhu, 1997; Preto, 1998). This is a forest ecology based climatic classification system.

4.1.2 Climate based territorial zoning

Vietnam carried out territorial zoning studies following a climatic specialized indicator called climatic classification in northwest of Vietnam (1964), natural climatic classification (Nguyen Huu Tai, 1985, Nguyen Duc Ngu & Nguyen Trong Hieu, 2004). This system is being applied in the entire country, with 7 climatic regions as follows: northeast, northwest, red river delta, north central region, south central coastal region, central highland and southern region.

A number of climatic classification studies for other sectors were completed as construction climatic classification (Tran Viet Lien, 1984, 2002), agricultural climatic classification (Le Quang Huynh, 1985), etc.

4.1.3 Hierarchic classification

According to Nguyen Huu Tai (1985), Nguyen Duc Ngu & Nguyen Trong Hieu (2004),

Vietnam's natural climatic zoning diagrams classification has a rather homogeneous criteria system, which could be described as follows:

- Climatic zone: is a hierarchic classification level that indicates climatic differences related to affect of winter monsoon, of which establishment of the two hot and cold seasons results from decreased temperature in winter.
- Climatic region: is a basic level of diagram that reflects climatic differences related to affect of summer monsoon, which leads to differences on rainy season in various region.
- Climatic sub-region: is an additional hierarchic classification level that aims to prescribe more details on climatic disintegration in each region through various climatic features.

4.1.4 Forest ecological stratification criteria and recommendations

- Climatic zone:

Main criteria on climatic zoning is annual temperature amplitude ($\Delta t^{\circ}\text{C}$). Criteria used to classify 2 zones is ($\Delta t=8^{\circ}\text{C}$), in addition, there are also 2 combined criteria as: average temperature of the lowest month (annual $T = 20^{\circ}\text{C}$), total average annual radiation($Q=9000^{\circ}\text{C}$) and total annual sunny hours ($S=2000$ hours).

- Climatic region:

Applicable criteria are: annual and daily temperature amplitude; average temperature of the lowest month. There are 8 climatic regions in the whole country and each region has its own indicators.

- Climatic sub-region:

- Applicable criteria are: annual and seasonal precipitation, total annual temperature, extreme and humidity indicators. These parameters are calculated from gauging stations derived data.

- Recommendations on forest ecological stratification:

Data is an important basis to test model, develop criteria system and identify boundaries. With rather large scale of 1/250000, the employed data must be grid data with adequate density (resolution of 15km). Data processing and adjustment according to measurement results plays a crucial role.

Zoning methodology targets at conventional methods under climatic-geographic methodology as analyzed above. Hierarchical classification system will follow general plan with 2 fundamental levels as region and sub-region. Methods and criteria systems of the world climatic classification diagrams of Koppen, Köppen-Trewartha, Holdridge; Vietnam climatic region classification maps with hierarchic classification system and zoning criteria are seen as important referential documents. **The study of ecological climate criteria and the combination of basic climatic characteristics that generate complexity to reflect the relation between climate and forest growth, yield shall be direction for development of hierarchical**

classification system and zoning criteria.

As proposed, climatic stratification for forestry sector comprises 3 hierarchy (zones, regions and sub-regions), indicators for each hierarchy is proposed in table 4. This method has indicated that the climate has a large impact on stratifying at zone and regional levels meanwhile having less impact at the sub-region level. The proposed criteria on forest ecological stratification are as follows (Tran Viet Lien *et al*, 2011).

Table 4. Climatic criteria for ecological stratification hierarchy

Hierarchy	Criteria
Zone	- Amplitude of average annual temperature (ΔT): 8°C - Annual temperature: 9000°C - Total sunny hours: 2000 hours
Region	- Average monthly lowest temperature - Amplitude of annual average temperature - Amplitude of daily average temperature
Sub-region	- Annual average temperature - Monthly average temperature in winter - Monthly average temperature in summer - Annual precipitation - Average precipitation in rainy season - Average precipitation in dry season - Potential Evapotranspiration Rate (PER)

In reality, climatic factors strongly affect large units of sub-region. It is hard to identify a typical climatic regime for each sub-region and as such, average features of the most common factors as temperature, precipitation are often described.

4.2 Topography - geomorphology

4.2.1 International and Vietnamese experiences

Topography-geomorphology factor group has the longest establishment process in the earth's forming history and is seen as a decisive factor to the forming of oceans, continents, shapes and material composition of the earth's crust. However, this topography-geomorphology group does not directly affect composition of various vegetation types while it does influence other factors such as climate, hydrology, parent material, soil, etc. relevant for forest ecology. The topography-geomorphology group affects establishment and composition of species as well as distribution of forest ecological system via the following

factors:

- Continent **location**: is a distance from that region to sea, affects sub-climate and establishes continent and ocean climatic based areas.
- Elevation, hilly direction and slope: are factors that affect sub-climate regime. Elevation establishes elevation belts with different climate and soil features that affect plants distribution. Under the Vietnamese context, the subtropical belt limit in low mountain area in the north is 600 - 700m, and 1,000m in the south because the south is closer to the equator. Thái Văn Trùng (1978, 1999) classified vegetations in one region into 2 large groups: latitude based vegetation group and elevation based vegetation group;
- Different parent material-forms lead to establishment of various soil types;

Geography/geomorphology factor group in our country affects forest ecological system through the following features:

- During the long-term and complicated forming process, favorable conditions have been generated somewhere, sometimes for conservation of primary vegetation types,
- Mountainous system of Vietnam is prolonged from a mountainous range of southern China and Himalaya range continuously from north to south, creating favorable conditions for flora migration flow into Vietnam's territory.
- Dominant topographical direction is northwest-southeast, perpendicularly with northeast windy direction so as to block cold air flowing from the north.
- Transect of Truong Son range is not symmetric with gentle sloping on the west side and steep sloping on the east side, which is close to coastal line. Therefore, protection is so crucial for central region.
- Due to the difficulties in accessing the existing limestone mountains in Vietnam, there still remain an endemic tropical forest ecosystem that could not be found in every country.
- Vietnam spreads over 15° latitude, therefore, the lower limit of the subtropical mountainous belt differs from north to south. It is 600 -700 m and 1,000 m in the north and south respectively.

4.2.2 Classification

The earliest study on geomorphologic zoning in the north part of Vietnam carried out by Nguyen Duc Chinh, Vu Tu Lap in 1963, subsequently, by M.A. Zubasenco in 1967, and Le Duc An in 1972, 1974, 1985.

The 2 most important criteria for topography/geomorphology based territorial zoning are: Shaping architecture (KTHT) and shaping sculpture (Patch).

Le Duc An conducted geomorphologic zoning in the north of Vietnam and divided into 57

areas. After the country's unification, he further researched and developed an integrated geomorphologic zoning for the entire country, initially continent part. (Le Duc An, 1979, 1985). Le Duc Anh conducted geomorphologic zoning following the 2 cited criteria because when dividing different hierarchic geomorphology units, he relied on relation between forming structure and its topography, development history, petrography compound as well as characteristics of exogenous processes and finally interaction results of these factors that illustrate territorial shape and elevation.

4.2.3 Hierarchic classification

Hierarchic classification of Le Duc An (1985) comprises: geomorphologic country; geomorphologic province and sub-province; geomorphologic zone and sub-zone. Soil Scientific Association (1993) classified geomorphologic zone into 4 hierarchy as: zone (2 zones), sub-zone (2 sub-zones), unit (16 units) and region (142 regions). Zoning criteria of various geomorphologic regions, natural geography and soil of these above mentioned authors are very diversified and could be described as follows:

- Geomorphologic region follows features of shaping sculpture and shaping architecture;
- Physical geographic region: characterized by a rather homogeneous shape type, soil type and vegetation.
- Pedologic *geography region* is integrated and homogeneous territory in terms of pedologic cover's structure, location within an agricultural land region, a common pedologic geography region, a main land type that is decisive for production direction.
- Criteria for dividing geomorphologic regions, physical geography, pedologic geography differ but all relate to geology/geomorphology. This is a high unification in terms of elevation and topographic shape (geomorphologic region) or a similar homogeneous topography type (physical geographic region) or an integrated territory (pedologic geographic region).
- Forest ecological regions and agricultural ecological regions spread over a much larger area than geomorphologic regions (including physical geographic region, pedologic geographic region) and even larger than geomorphologic zone or pedologic geographic unit or Central highland's physical geographic unit.
- Zoning percentage is small in proportion (1/1,000,000 and 1/500,000) in comparison with the planned proportion of the forest ecology stratification study of 1/250,000.
- According to geomorphologic classification diagram of Le Duc An, there are 9 zones and 16 sub-zones. The pedologic geographic diagram of the Vietnam Soil scientific Association also comprises 16 pedologic geographic units but distribution boundaries of geomorphologic sub-zones and pedologic geographic unit are different.
- From 16 geomorphologic sub-zones, Le Duc An divided into 92 geomorphologic regions. Meanwhile, from 16 pedologic geographic units, authors from the Vietnam Soil

Science Association divided this into 142 pedologic geographic regions because geomorphologic zoning means individual sector zoning. As such, when stratifying forest ecology, it is necessary to have homogeneity of various natural factors in order to have higher number of forest ecological units at corresponding geomorphologic region.

- As indicated in the soil geographical zoning map, the central highland region consists of 3 geographic units and 20 geographic regions. Boundaries of geographic units and regions nearly coincide with the 3 natural geographic units and 21 natural geographic regions although the study was conducted under 2 different scale and target groups. Both of these zoning methods have higher synthesis view than that of the geomorphologic zoning method.

4.2.4 Criteria and recommendations on forest ecological stratification

The following table describes criteria are used for stratification of topography and geology in Vietnam:

Table 5. Geological/geomorphological criteria for forest ecological stratification

Classification	Criteria
Zone	Homogeneity of topographic provenance and tectonic particularities
Region	Homogeneity of terrain morphology (mountains, hills, highlands, plain...)
Sub-region	Homogeneity of lava, topographic types and lava and high belts

Source: Nguyen Dinh Ky, Lai Vinh Cam, 2011

4.3 Soil - site

Soil and site are two different elements which are closely interactive. Thus, they are usually studied as the same integrated ecological factor. On the other hand, soil classification and site classification also belong to 2 different theoretical systems, and herein, this study mainly refers to only impacts of soil conditions and soil stratification on criteria and system for forest ecological stratification in Vietnam.

4.3.1 International and national experiences

As stated by Do Dinh Sam, Nguyen Xuan Quat, Dinh Thanh Giang (2011), the world soil classification has 3 key tendencies, **that are:**

- Biology-based soil classification (also known as comparative geographic method by the Docutrap VV.) with 5 elements arising from climate, parent material, relief, organisms and time factor which are the first 5 important criteria for natural soil classification
- Taxonomy soil classification (U.S.) according to the point of view on characteristics

quantification and qualitative diagnosis of emerging soil classes based on the relationship between soil properties and soil transect morphology to classify soil types.

- FAO – UNESCO soil classification is an international classification system in accordance with Soil Taxonomy standards which is based on soil property quantification and soil classification diagnostic signals according to soil groupings, type etc. FAO – UNESCO soil classification is an international classification system in accordance with Soil Taxonomy standards which is based on soil property quantification and soil classification diagnostic signals according to soil groupings, type, etc.

Vietnam's soil classification (actually that is zoning) underwent 3 phases:

- Before 1954, the French's study began mainly focusing on biological conditions which developed soil properties, classifying into different soil groups, for example, lateritic Ferralsols and Fluvisols discovered by Castagnol EM (1950)
- From 1954 to 1975, the North conducted a soil classification according to emerging geography developed by Fritlan VM and Vietnamese pedologist (1959). The South's soil classification was affected by the school of Soil Taxonomy led by Moormann FR (1960)
- From 1975 to 2010, the soil classification nationwide was finished to develop Vietnam's soil map with the scale 1/1000.000 (1980) according to biological viewpoint to have 13 groupings with 30 soil types and national soil classification sheet based on the quantitative FAO-UNESCO-WRB (1998), which both connects and integrates into the close connection with the aforesaid classification method

Vietnam's soil classification system has 4 levels: groups – types (unit) – subtype – variants. Groups and types conform to international conception and criteria and suitable for Vietnam's conditions. Subtypes reflect level and depth of conglomeration, either much or little or shallow or deep gley. Variant use the relation of physical soil elements which have relation with parent rock according to 3 levels or 6 levels.

Regarding site classification, Vietnam has absorbed 3 trends which are different in levels of classification, criteria and indicators:

- Method of forest site zoning with 4 unit levels transferred by Germany since 1970 has been so far effectively used nation-wide.
- The former Soviet Union school developed by Tchertov (1977.1981) has been tested with three criteria: parent rock, topography and drainage.
- Recommendations from research and practical classification of the 6 site levels by Nguyen Van Khanh (1996)

4.3.2 Classification

Vietnam has 2 soil classification systems, including i) biology-based soil classification with the scale of 1/1,000,000 (the working group responsible for Vietnam's soil map development, 1976). This system has 13 soil groupings and 30 soil types; and ii) FAO-

UNESCO classification system

ii) FAO-UNESCO-based soil classification system (the Agriculture Planning Institute 1998)

FAO-UNESCO-based soil classification system, 1998 has the 4 following levels:

- Major soil groupings
- Soil unit, equivalent to soil series according to biology-based soil classification
- Soil sub-units
- Soil phase

“Soil unit” is a fundamental taxon unit. The classification sheet has 21 major soil groupings and 61 soil units. Out of 61 soil units, 28 soil units are related to forest production. See details of soil groupings and units in [Annex 1](#) and soil unit distribution map in [Annex 2](#).

4.3.3 Geographical soil stratification

The soil and geographical stratification system includes 4 levels, namely Zone, Sub-zone, Unit and Region. Based on soil classification map with the scale of 1/1.000.000, the working group for soil map development has developed the draft soil geographic stratification. This stratification has the following features:

- Zone: the 2 different soil geographic zones, i.e. the Northern soil geographic zone and the Southern soil geographic zone, is divided by a natural boundary of Hai Van Mountain Pass
- Sub-zone: the 2 zones are divided into 6 subzones which have different climates, hydrograph, soil and organisms. The North has 3 subzones while the South has also 3 sub-zones.
- Unit: the subzone is divided into different units which have different geology and geomorphology and agricultural land use purposes. The North has 8 units while the South has 8 units
- Region: region is the lowest level. Based on Vietnam’s soil map scale 1/1,000,000 established nation-wide in 1976, there are 146 zones of 16 geographic soil units

4.3.4 Site zoning

Site is a specific territorial scope which have all surrounding factors affecting the growth of organisms, mainly flora. In the narrow sense, site includes 3 elements, namely climate, topography and soil. In the broader sense, site consists of 4 elements, i.e. climate, topography, soil and fauna and flora world.

The forest site zoning discovered by German experts in Vietnam in 1970 is the 4-level hierarchy:

- Growing region

- Growing area
- Patch area
- Site unit.

The authors classified the North into 7 growing regions and 22 growing areas.

The site zoning proposed by Nguyen Van Khanh (1996): the 6-level hierarchy is as follows: Zone, Subzone, Region, Sub-region, land form and site unit.

4.3.5 Criteria and recommendations on forest ecological stratification

Experts specialized in soil and site conditions realized that the region hierarchy is divided by the length of 15 latitude since this division created two different climate zones, i.e. a typical tropical zone in the south, non-typical tropical zone (1-3 month winter) in the North, however, there are unclear differences in soil and site classification as well as big altitude differentials to form typical tropical and subtropical soil classes. Therefore, Region and Sub-region mainly get soil and site factors contributed to forest ecological stratification through biology-based soil classification criteria 13 soil group (sub-units) and 30 soil types.

The 3 following bases are used to propose soil and site criteria for forest ecological stratification:

- Classification of forest types or natural ecosystems.
- Hierarchy selected for the purpose of research.
- Relation between soil types and forest types, in general term, relation between land and flora population.

The first 2 bases have been identified as mentioned above whilst the 3rd base is the proper law between organisms and surrounding environment. Each soil type is only suitable for one or some certain forest types. Vice versa each forest type can grow on one or some certain soil types.

Findings are to be integrated to propose classification, selection and hierarchy and map development.

Principle of classification hierarchy

Zone, Region and Sub-region are 3 key units of the classification hierarchy. Forest ecological stratification is required to be relied on a basic unit, on which superior and inferior units shall be identified according to a hierarchy system. Thus, forest ecological area is supposed to be basic unit. Then the superior units are unit and further zone respectively. In this proposed table, sub-region is temporarily considered basic unit, then its superior units are region and zone since if sub-region is called region, region must be so-called unit which is now not familiar with foresters)

Criteria for forest ecological stratification:

- There is relative homogeneity of geological and geomorphologic structure as well as historical development, creating a great topographic morphology characterized by a trivial distinguishment of climate and soil conditions reciprocally affected by atmosphere circulation and topography;
- There are similarities of provenance, development history and flora population structure
- There are community characteristics in common, generating homogeneous technical impacts on nature
- There is territorial integrity in ecoregion delineation. One eco-region should be delineated by one single polygon. If there are 2 similar eco-regions but are spatially disconnected they should be considered as 2 different eco-region. Areas with distinct ecological condition but relatively small will be merged to the main eco-region. Their characteristic will be described in the text but will not be mapped.

Criteria for sub-region stratification:

- There is the same type of relatively homogenous landscape in terms of parent material and topographic patterns; sub-climates; soil unit and flora population
- There is relative homogeneity of humidity and key factors which form forest type and yield
- There are boundaries being fully enclosed in a forest ecological zone, ensuring no spatial separation against another sub-region
- There are similar land use methods

Table 6. Proposed soil criteria and indicators for forest ecological stratification

Hierarchy	Criteria	Description
Region	Select at least 3 out of 13 major soil groupings (according to FAO/UNESCO)	I. Arenosols; II. Solochats; III. Fluvisols; IV. Thionic Fluvisols; V. Gleysols; VI. Histosols; VII. Luvisols; VIII. Lixisols; IX. Calcisols; X. Acrisols; XI. Ferralsols; XII. Alisols; XIII. Leptosols.
Sub-region	Select at least 2 out of 28 soil units in accordance with FAO- UNESCO.	1. Luvic Arenosols; 2. Rhodic Arenosols; 3. Haplic Arenosols; 4. Gleyic Solochats; 5. Proto-thionic Gleysoils; 6. Orthi-thionic Fluvisols; 7. Dystric Gleysols; 8. Umbric Gleysols; 9. Fibric Histosols; 10. Thionic Histosols; 11. Ferric Luvisols; 12. Calcic Luvisols; 13. Chromic Luvisols; 14. Luvic Calcisols; 15. Haplic Calcisols; 16. Haplic Acrisols; 17. Ferralic Acrisols; 18. Gleyic Podzoluvisols; 19. Rhodic Ferralsols; 20. Xanthic Ferrasols; 21. Plinthic Ferrasols; 22. Humic Ferrasols; 23. Humic Arisols; 24. Humic Alisols; 25. Gleyic Alisols; 26. Histric Alisols; 27. Haplic Nitisols; 28. Lithic Leptosols

4.4 Forest ecological stratification

4.4.1 National and international experiences

Forest ecological stratification is very similar to agricultural ecological stratification since they both aim at conservation and sustainable land use, higher productivity of plant ecosystems as well as use of natural resources and social resources;

Territorial zoning was finished and put into use in the early and middle of the twentieth century in the countries with the high forest cover, especially in the developed countries, where the forest sector made a high contribution to the national economy such as Sweden, Norway, Finland, USSR, Canada, the United States, etc. The differences in objectives, activities and territorial scope have resulted in different names such as forest zoning, forest economy zoning or forest ecological stratification etc.

The Former Soviet Union which has a large area of forests attained many achievements in forest zoning regarding all thematic expertise not only for the entire Soviet Union, but also for their individual republic countries.

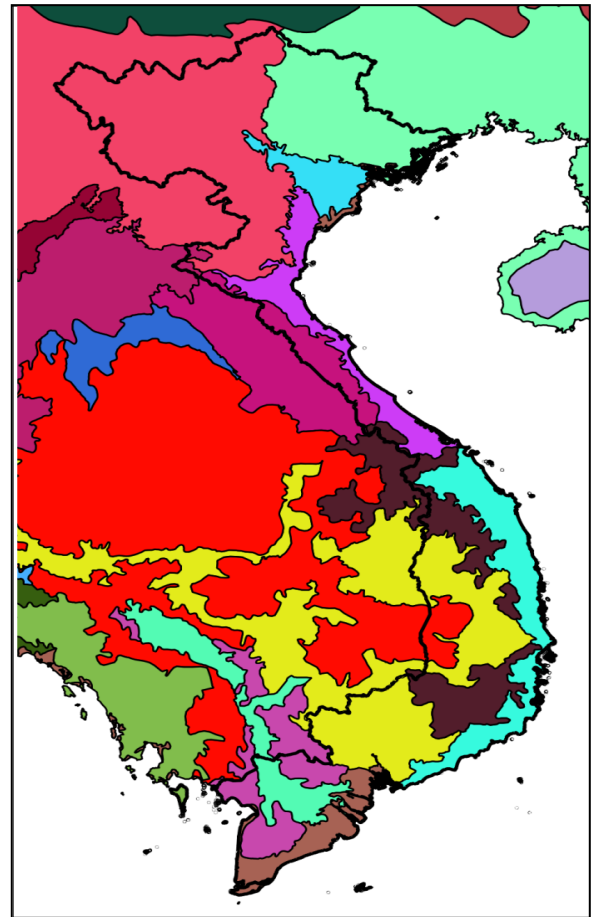
According to Lai Vinh Cam, ecological region is defined as a specified geographical region which is smaller than ecological zone but larger than ecological system. As defined by Omernik (2004), ecological region is the region which has a spatial homogeneity of geographical features but a differentiation of ecosystem health and integrity condition. Geographical characteristics may include geology, physical geography, vegetation, climate, and hydrology. The terrestrial fauna and aquatic ecoregions, soil, and with or without human interventions (eg land use, vegetation change ...) .

In 2001, WWF has completed the Ecoregions of the World. The system consists of relatively large region units which have specific characteristics of geography, climatic conditions and typical natural populations. The ecological region is required to reflect a natural distribution of organism species and populations under human interventions. The Ecoregions of the World has many applications in ecology and biodiversity studies:

- Provide a geographical and biological basis for the large-scale conservation strategies
- Provide maps as a basis for planning conservation projects at global and regional levels
- Provide a scientific basis of natural conditions of ecoregions, including climate, soil, vegetation, animals, current status and threats affecting natural ecosystems.

According to the stratification, WWF divided the land surface of the earth into 8 ecological zones (ecozone) with 867 eco-regions and about 450 aquatic ecoregions worldwide. Vietnam has 13 ecological zones as follows:

1. Subtropical evergreen forests of South China - Vietnam
2. High mountainous humid forests Luang Prabang
3. Humid forests North of Annamites
4. Sub-tropical forest of North Indochina
5. Freshwater swamp forests of the Red River
6. Mangrove forests of Indochina
7. Lowland humid forests of North Vietnam
8. Dry forests of Central Indochina
9. High mountainous humid forests of South Annamites
10. Dry evergreen forests of Southwest Indochina
11. Brackish water swamp forest Tonle Sap Mekong
12. Freshwater swamp forest Tonle Sap
13. Lowland dry forest of South Vietnam



WWF's stratification indicated that the aforesaid outcomes have been implemented at a large scale (global scope). Therefore, it is general. Therefore, scientists from many countries continue doing researches in more details as well as stratifying at a larger scale. Reviewing and assessing the research findings play an important role in forest ecological stratification in Vietnam.

Before 1975, the Directorate of Forestry would usually use the concept of "forest area" to refer to an administrative unit where many forest operations are centralized for the aims of management, planning and development, especially the forest area Song Hieu (Quy Chau and Quy Hop districts) in Nghe An province in Vietnam.

After 1975, a series of similar forest areas were established in the South of Vietnam after the national unification. These areas were characterized as a forest economic zone and security area. Then they were shifted into corporation. There were no methods and criteria for zoning but planning for timber-densed area, which is not characterized by territorial zoning.

The 2nd concept of the 9 forest zones covering the entire territory has been used for forest sector master planning and management and since 1970s. It is very similar to the concept of territorial zoning according to forest economics concept. However, it is paradoxical that no actual stratification works, methodologies and criteria as well as no legal approvals by any competent agencies have been available over many years. The reason might be that they are

very similar to 7 agro-ecological zone as well as similar to 7 natural climate regions. Therefore, they still managed to promote their efficiency.

In short, the number of provinces and their names in certain forest zones had been changed many times during the administrative separation and integration process. However, they are now as follows:

- North-west: including 4 provinces Hoa Binh, Son la, Dien Bien, Lai Chau.
- North-east: including 12 provinces: Cao Bang, Lang Son, Bac Can, Thai Nguyen, Quang Ninh, Bac Giang, Lao Cai, Yen Bai, Ha Giang, Tuyen Quang, Phu Tho, Vinh Phuc.
- Red river Delta: including 9 provinces: Hai Phong, Hai Duong, Bac Ninh, Hung Yen, Ha Noi, Thai Binh, Nam Dinh, Ha Nam, Ninh Binh.
- North Central Region: including 6 provinces: Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien-Hue.
- South Central Region: including 8 provinces: Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa, Ninh Thuan, Binh Thuan.
- Central Highland: including 5 provinces: Lam Dong, Dak Nong, Dak Lak, Gia Lai, Kon Tum.
- South-east: including 6 provinces: Ba Ria Vung Tau, Dong Nai, Binh Duong, Binh Phuoc, Tay Ninh, Ho Chi Minh city.
- South-west: including 13 provinces, i.e. Long An, Ben Tre, Dong Thap, Soc Trang, Vinh Long, Can Tho, Hau Giang, Tien Giang, Bac Lieu, Ca Mau, Kien Giang, An Giang, Tra Vinh.

4.4.2 Forest ecological stratification

This part refers to Vietnam territorial zoning into smaller area units, forest ecosystem of which is more homogeneous. This also serves as a basis for forecasting bio-production of ecosystems and non-forest site. Therefore, the Section 2 refers to Vietnam's ecological stratification categories. The Section 3.3 also presents methods, results and scope of application of forest classification systems, as well as interprets the selection of forest ecosystems to be classified in accordance with the forest sector Manual (which is supplemented with existing ecosystems in the territory of Vietnam) thanks to the scientific and practical characteristics of the systems.

4.4.3 Justification of stratification hierarchy

The impetus for this study has been the stratification of the national territory for purposes of developing Reference Emission Level (REL) and supporting to Measurement, Reporting and Verification (MRV).

Another issue is how to use stratification for sector planning and macro-management without aiming to identify total biomass or emission of specific forest management agencies and business entities. Therefore, according to the 7-level stratification hierarchy as regulated by the Circular No. 193/UB-VP, this study has selected Region and Sub-region (equivalent to ecological landscape level). They are two average levels which are considered as baseline level in many studies.

Firstly, it is required to compare the number of hierarchical units among 8 forest ecological regions, 7 agricultural ecological regions and 7 natural climate regions:

- Former Northern Part: Forestry: 3 regions (North-west, Northeast, Delta); Agriculture: 2 regions (Midland-Mountains, Delta); Climate: 3 regions (North-west, Northeast, Delta).
- Central: The 3 aforesaid sectors are distributed in 3 different regions (North Central, South Central and Central Highland).
- South Central: Forestry: 2 regions (Northeast, Southwest); Agriculture: 2 regions (Northeast, Southwest); and Climate: 1 region (Southern).

Basic ecosystems of natural forests were formed long time back. Their evolution and degradation are both dependent on external conditions. The forest ecological stratification can not be separated from results of meteorological-hydrological, geological-topographic and soil-site zoning, which have been comparatively studied under Sections 4.1 and 4.2

Therefore, the criteria for forest ecological stratification, in general, and the criteria for stratification hierarchy, in particular, are relevant to respective criteria for the foresaid zoning. The boundaries of each hierarchy unit are mainly either equivalent or coincident. This creates favorable conditions for other zoning in the coming time.

Forest ecologist discovered that many tree species and forest types of the North and South have significant differences in size (height, diameter, weight, biological yield), for instance, mangrove forest ecosystem, mixed evergreen broad-leaved forest in the low Central Highland and Southeast regions. Therefore, the category of Zone is selected to be the largest unit of the forest ecological stratification system in this study.

According to the use of scientific background for dividing into 2 zones as specified in Section 4.1 in combination with seasonal growth pace of forest trees, we propose Bach Ma Mountains to be a natural boundary of forest ecological zones (boundary distinguishing between Thua Thien Hue and Quang Nam, Da Nang city).

5 Criteria for forest ecological stratification and map development method

5.1 Criteria for forest ecological stratification

Forest ecology is conceived as a field which is closely related to the concept of ecological landscape in general, as well as is an important part of ecological landscape, therefore, in addition to its own particular functions, the forest ecosystem also has functions of an ecological landscape as follows:

- Natural function: existence and transformation of landscape elements such as climate, hydrology, soil, topography, geology, etc.
- Functions of natural and man-made habitats of all landscape structures as mentioned-above;
- Function of bio-production function, metabolism and system functions
- Socio-economic functions: function of provision;
- Aesthetic function: creation of beautiful natural and man-made landscapes;
- Functions of storage and metabolism of wastes

The ecological factors are considered the factors arising from the formation and development of ecosystems which have been studied and selected. Accordingly, criteria are to be considered during the forest ecological stratification includes: i) climate; ii) topography and geomorphology; iii) Soil – site, and iv) typical flora vegetation.

When using the results of forest ecological stratification, the stratification hierarchy which has practical significance is used for strategic master planning. Region category is usually used for developing and planning large scale programs. Sub-region which is equivalent to landscape site and ecological landscape is often used for develop small-scale projects. In addition, territorial particularities are not only within forest ecological stratification, but also in many other types of zoning which are ecological zone, namely North and the South divided by Hai Van Pass

Criteria for Ecological Zone stratification:

- Use of criteria and indicators for dividing Zones of natural climate region stratification is adequate ($\Delta t=8^{\circ}\text{C}$, total annual temperature $Q=9000^{\circ}\text{C}$, total sunshine time $S=2000$ hours).
- Out of the forest ecological stratification, the 2 categories of region and sub-region are proposed to be main units of the stratification hierarchy.

Criteria for Ecological Region stratification:

- Having territorial integrity (no repeat);

- Having relative homogeneity of geological architecture, creating a great topographic form characterized by the insignificant distinguishment of climate, soil and forest vegetation;
- There is one or two typical forest ecosystems in the regions stratified according to latitude and elevation (additional);
- Having relative homogeneity of forest development planning.

Criteria for Ecological sub-region stratification:

- Having a the same type of relative homogenous landscape in terms of parent materials and topographic forms; sub-climate; soil unit and flora population;
- Having territorial integrity (no repeat) within the region;
- Having relative homogeneity of forest types and yields;
- Having boundaries enclosed within a forest ecological region;
- Having homogeneity of land use approaches.

Based on the analysis of each criterion for the forest ecological stratification as specified in Section 4, the research team has integrated them into a criteria toolkit for forest ecological stratification. This toolkit is indicated in Table 7 and used for the stratification with three-level hierarchy, namely ecological zone, eco-regions and eco-subregions. Ecological sub-region is the basic unit to determine typical forest types which have a relative homogeneity, serving as a basis for calculating emissions and developing the emission reference line and also as a basis for supporting the **measurement**, reporting and verification (MRV).

Table 7. Criteria for forest ecological stratification in Vietnam

Hierarchy	Criteria	Indicator	Theory and Practice
Zone	Climate	- Average annual temperature amplitude ¹ (ΔT) is 8°C - Total annual temperature is 9000°C - Total sunlight is 2000 hours	- Typical tropical climate - Continuous forest growth - Eco-system preliminary productivity
Region	Climate	- have the same regional climate region	- Regional climate condition development
	Topography	- have the same topographic forms	- Local characteristics
	Forest ecosystem	- Integrity and no repeat of eco-systems - 1-2 major types/sub-types - Have planning and management practices	- Natural ecosystem distribution - Directions of macro-level planning, development and management

¹ Average monthly highest temperature minus average monthly lowest temperature

	Land	- Have at least 2 soil groups out of 13 soil groups (FAO/UNESCO)	- Having impacts on forest ecosystem distribution and productivity
Sub-region	Climate	- Have the same particular climate conditions	- Investment in sub-regional climate condition development
	Land	- Have at least 3 land units out of 28 soil units (according to FAO/UNESCO)	- Soil resources for development planning
	Topography	- have the same elevation belt topographic conditions.	- Easy to recognize, reflect the ecosystem distribution.
	Forest ecosystem	- Integrity and no repeat of ecosystems - Having 1-2 key forest types for planning and development	- REL research - Basis for forest development and ecosystem conservation

5.2 Ecological mapping and database development method

During the data analysis, the researchers studied the ability to determine ecological regions through the spatial analysis and multi-criteria analysis methods. However, the process of experiment and discussion among experts shown that the aforesaid two methods have some limitations which are difficult to be put into use in this research for the following reasons:

- Patchiness character and heterogeneous character of ecological regions: each ecoregion covers a relatively large area (average area is larger than an area of a province), so a specific region has many changes both in natural conditions and natural ecosystems. If absolute quantitative values are used employing the spatial analysis approach, many small regions would be created, which are very difficult to be detected and merged into large ecological regions which are of representative on a geographic region.
- Spatial analysis method and weight-based grading method will produce results in such forms of scores or indexes. Scores/indexes.
- These scores/indexes can be very useful in classification studies (high, low, medium) or in maps which have contours used, for instance, to reflect climate conditions. However, in case of zoning, transferring scores into regions not really feasible.

For the reasons as mentioned above, the research team decided to apply experts' knowledge to determine regions and sub-regions. After relative positions of regions and subregions are identified, GIS data will be used to exactly and precisely determine boundaries on a map based on limiting factors. Basic steps of stratification map development which apply experts knowledge in combination with GIS database include as follows:

Step 1 – Ecological zone zoning

Ecological zone zoning is based on climatic factors, using the annual average temperature range of 8°C for zoning. Additional supporting criteria such as the total annual temperature of 9000°C and total sunshine of 2000 hours are also to be used. These criteria remarkably

reflect climate characteristics of the North and the South which are also indicated through the forest vegetation growth in these two regions. This zoning 2 is very clear and be used by many industries

Step 2 – Ecological region zoning

Zoning into eight major ecological regions is based on climatic factors (see climate zoning in Section 4.1 for detail). After identifying eight climate zones, we use expertise knowledge to re-adjust natural boundaries of these regions.

For example, according to the adjustment in the Northwest, the entire Hoang Lien Son Mountain Range belongs to the Northwest, while according to the former agro-climate region zoning, a half of Hoang Lien Son range belongs to the northwestern and the rest is located in the Northeast.

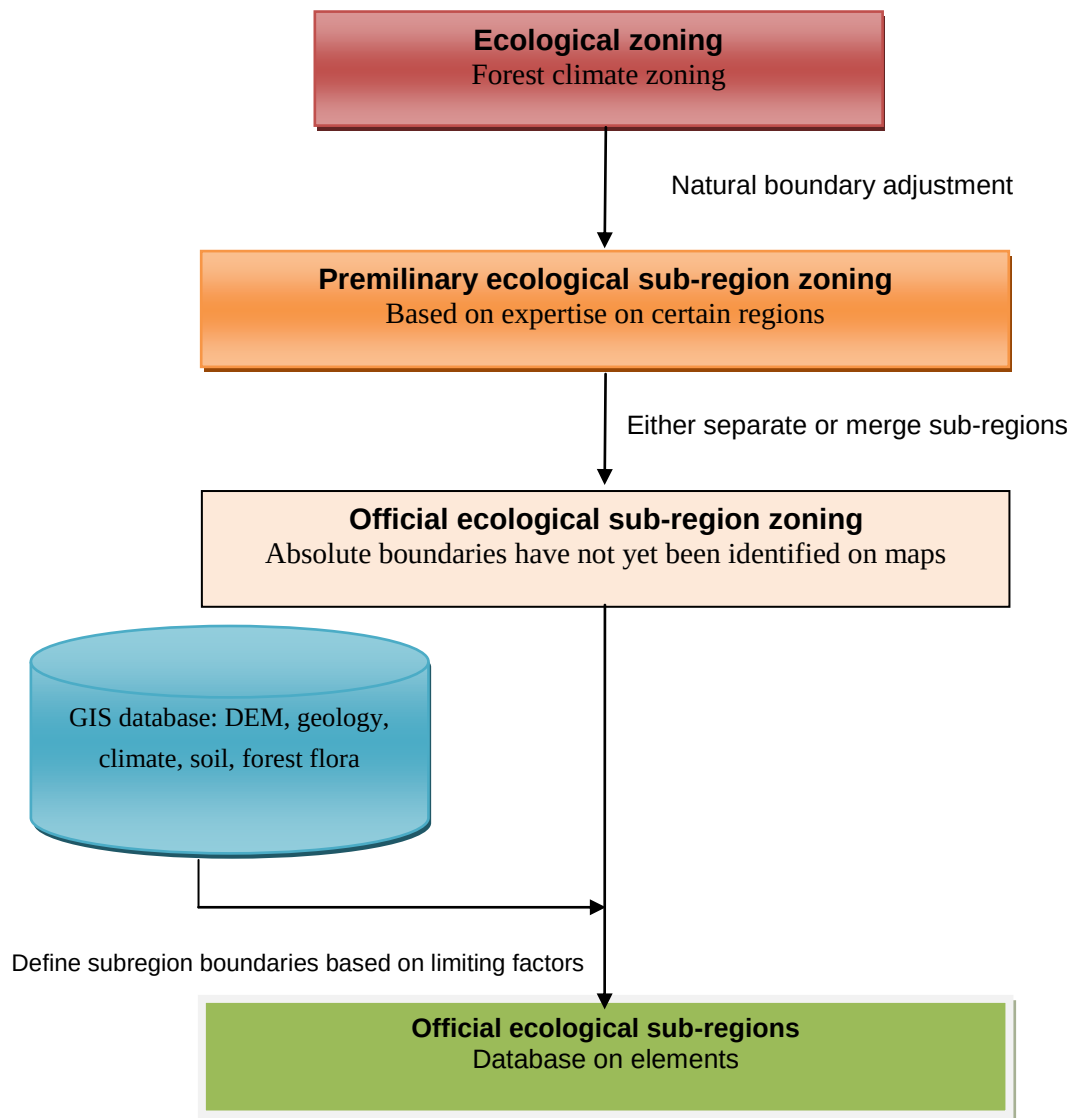
Step 3 – Ecological sub-region zoning

After determining regional boundaries, sub-regions are to be defined based on expertise knowledge. In case of the regions which are not very large, the working group will discuss and propose different options on sub-region zoning and sketch the boundaries on the map. Based on the preliminary sub-regions, the working group will further investigate into such elements as geomorphology, geology, climate and ecosystems. Then sub-regions shall be either separated or merged until they are eligible for the criteria as specified in the Table (table name) and as agreed by the working group.

GIS is used to identify specific boundaries on the basis of limiting factors. For example: i) Muong Xen sub-region is characterized by dry and drought natural conditions due to hot and dry westerly wind from Lao, the Isomorous line of the drought index is used to determine boundaries ii) in case of limestone mountainous Phong Nha - Ke Bang sub-region, the boundaries of the limestone blocks on geological maps are used to define boundaries; iii) in case of the upstream sub-regions of Da and Ma rivers, we use the catchment boundaries to determine basin boundaries; iv) in case where sub-regions have the partition between plains, hills and mountains, digital elevation model is used to determine boundaries between different types of terrains.

Step 4 – Development of data tables on ecological region and subregion description

After finalizing region and sub-region maps, we proceed to develop element database for each region and each sub-region, including climate, geomorphology/ geology, soil condition and ecological characteristics. The information on climate and soil conditions is extracted from GIS database, while in case of other remaining elements which are descriptive, for instance, geomorphology/ geology and ecology, each thematic working group shall use their expertise and professional knowledge to describe such elements.



6 Results and discussion

6.1 Forest ecological stratification

Based on criteria and methods of forest ecological stratification as described in Section 5 above, the working group conducted a forest ecological stratification for the entire territory of Vietnam. The results are summarized as follows:

- Vietnam's territory is divided into two ecological zones; the boundary between the two ecological zones is the Hai Van Pass and Bach Ma mountain range which belong to Thua Thien Hue province, Quang Nam province and Da Nang city.
- There are eight forest ecoregion: i) the northwest region inclusive of Dien Bien, Lai Chau, Son La and Hoa Binh provinces ii) the northeast region inclusive of Lao Cai, Yen Bai, Ha Giang, Tuyen Quang, Phu Tho, Vinh Phuc, Cao Bang, Lang Son, Bac Can, Thai Nguyen, Quang Ninh and Bac Giang provinces; iii) the River Delta region including Hai Phong, Hai Duong, Bac Ninh, Hung Yen, Thai Binh, Nam Dinh , Hanoi, Ha Nam and Ninh Binh provinces; iv) the North Central region including

Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri and Thua Thien Hue provinces v) the South Central region including Quang Nam, Da Nang, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa, Ninh Thuan and Binh Thuan provinces vi) the Central Highland inclusive of Kon Tum, Gia Lai, Dak Lak, Dak Nong and Lam Dong provinces vii) Southeast region Ba Ria - Vung Tau, Dong Nai, Binh Duong, Binh Phuoc, Tay Ninh provinces and Ho Chi Minh city, and viii) the southwest including Long An, Ben Tre, Dong Thap, Soc Trang , Vinh Long, Can Tho, Hau Giang, Bac Lieu, Ca Mau, Kien Giang and Tra Vinh provinces.

Basically, the eight forest ecoregions in this study are relatively similar to the eight agricultural ecoregions which had been used before. However, the working group has made some changes in order to better adapt to natural conditions, regional boundaries are defined based on natural boundaries instead of administrative boundaries in some regions. See Table 8 and the map below for further details.

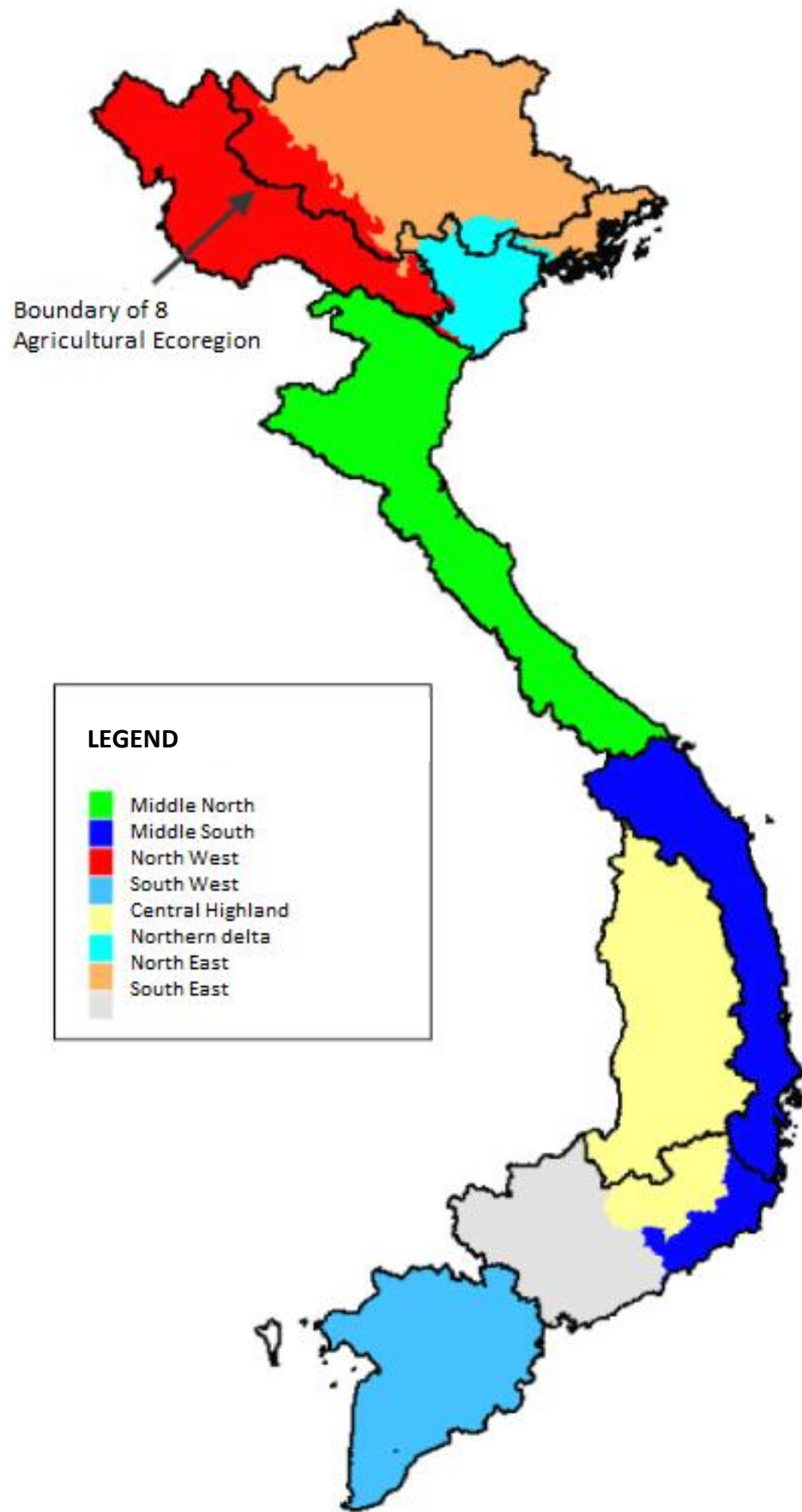
Table 8. Differences between Agricultural and forest ecological regions

Regions	Agricultural ecological region	Forest ecological region
1. Northwest	The boundary between the Northwest and Northeast is the administrative boundaries among Lai Chau, Lao Cai and Son La provinces	The Hoang Lien Son mountain Range entirely belongs to the Northwest. The Northwest region includes a part of Lao Cai, Yen Bai, Phu Tho provinces. From the ecological viewpoint, That the Hoang Lien Son Mountain Range is zoned into a entire region is more suitable in terms of climate, geology/topography and ecosystem distribution
2. Northeast	The boundary between the Northwest and Northeast is the administrative boundaries among Lai Chau, Lao Cai and Son La provinces	This region includes the former Northeast region exclusive of the Hoang Lien Son Mountain Range which is shifted to the Northwest region
3. Red river delta	Ha Tay, Ha Noi, Hung Yen, Hai Duong, Hai Phong, Ha Nam, Thai Binh, Nam Dinh	This region is basically as the same as it was under the former zoning. However, this region includes additional Bac Ninh province and a part of nature lowland plain of Bac Giang province
4. North Central Region	No change	

5. South Central Region	Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa	This region includes additional Ninh Thuan and a part of Binh Thuan province. According to the research team, Ninh Thuan and Binh Thuan provinces are characterized by narrow coastal lines of the South Central Region, dunes mixed with narrow plains, dry climate and high solar radiation resistance; therefore, they are supposed to belong to the South Central Region instead of the Southeast Region.
6. The Central Highland	Kon Tum, Gia Lai, Dak Lak, Dak Nong	Lam Dong province is added to the Central Highland Region since its characteristics such as high mountainous terrain and geology with many basalt rocks are more characterized by the Highland.
7. Southeast	Tay Ninh, Binh Phuoc, Lam Dong, Dong Nai, Binh Thuan, Ba Ria - Vung Tau, HCM city, Binh Duong	Lam Dong province is shifted to the Central Highland and a part of Binh Thuan province which has dry climate is shifted to the South Central Region.
8. Southwest	No change	

- There are 47 sub-ecoregions, of which the Northwest is divided into six sub-regions (sub-region 1, sub-region 2, sub-region 3, sub-region 4, sub-region 5 and sub-region 6); Northeast includes 10 subregions (sub-region 7, sub-region 8, sub-region 9, sub-region 10, sub-region 11, sub-region 12, sub-region 13, sub-region 14, sub-region 15 and sub-region 16); Red river delta includes 2 sub-regions (sub-region 17 and sub-region 18); North Central Region includes 6 sub-regions (sub-region 19, sub-region 20, sub-region 21, sub-region 22, sub-region 23 and sub-region 24); South Central Region includes 4 subregions (sub-region 25, sub-region 26, sub-region 27 and sub-region 28); the Central Highland includes 11 sub-regions (sub-region 29, sub-region 30, sub-region 31, sub-region 32, sub-region 33, sub-region 34, sub-region 35, sub-region 36, sub-region 37, sub-region 38 and sub-region 39); and Southeast includes 5 sub-regions (sub-region 40, sub-region 41, sub-region 42, sub-region 43 and sub-region 44); and Southwest includes 3 subregions (sub-region 45, sub-region 46 and sub-region 47).

Out of 47 sub-regions, 4 of them are islands and archipelago, that is sub-region 15 (northeast archipelago); sub-region 28 (Hoang Sa and Truong Sa archipelago); archipelago 44 (Con Dao) and sub-region 47 (Southwest Island).



Names and area of forest ecological regions and sub-regions are defined in details in Table 9 and forest ecological stratification map is shown as bellows:

Table 9. Name and area of forest ecological sub-regions

Region Subregion code	Name of sub-regions	Area (ha)
I. Northwest		4,586,350
Subregion 1	Da river upstream	1,782,913
Subregion 2	Ma river upstream	381,064
Subregion 3	Son La - Moc Chau Plateau	364,912
Subregion 4	Da River Valley	699,692
Subregion 5	Hoang Lien Son mountain Range	935,104
Subregion 6	Ninh Binh and Hoa Binh hilly terrain	422,664
II. Northeast		5,698,492
Subregion 7	Red River and Chay River Valleys	436,154
Subregion 8	Medium high mountain Hoang Su Phi	388,928
Subregion 9	Lo and Gam Rivers upstream	918,815
Subregion 10	Low Mountains Bao Lac, Ba Be	1,105,941
Subregion 11	Limestone Mountain Dong Van	384,386
Subregion 12	Midland including Phu Tho, Thai Nguyen, Vinh Phuc and Bac Giang	896,377
Subregion 13	Limestone Mountain Bac Son	393,098
Subregion 14	Low Mountains Cao Bang, Lang Son and Quang Ninh	931,841
Subregion 15	Northeast coastal mangroves	151,947
Subregion 16	Northeast Island	91,005
III. Red river Delta		1,352,475
Subregion 17	Red river delta	1,318,140
Subregion 18	Mangrove forests of the Red river delta	34,335
IV. North Central Region		5,063,188
Subregion 19	Muong Xen	301,798
Subregion 20	Mountainous Area to the west of Thanh Hoa, Nghe An and Ha Tinh provinces	1,943,353
Subregion 21	North Central hilly terrain	1,090,979
Subregion 22	Delta and coastal sandy dunes of the North Central Region	827,413
Subregion 23	Limestone Mountain Phong Nha – Ke Bang	148,573
Subregion 24	The mountain range to the West of Binh Tri Thien	751,073
V. South Central Region		3,686,832

Region Subregion code	Name of sub-regions	Area (ha)
Subregion 25	The Mountain Range to the west of Quang Nam and Quang Ngai	412,209
Subregion 26	Hilly terrain of the South Central Region	2,536,153
Subregion 27	The plain and coastal sandy dune of the South Central Region	738,469
Subregion 28	Hoang Sa and Truong Sa	n/a
VI. the Central Highland		5,327,223
Subregion 29	Extreme dry subregion of the South Central Region	309,456
Subregion 30	Ngoc Linh Mountain Range	591,057
Subregion 31	Sa Thay low mountain	652,742
Subregion 32	Plateau basalt Pleiku, Kon Ha Nung	550,492
Subregion 33	An Khe Low Mountain	284,810
Subregion 34	Penepains Cheo Reo, Phu Bon and Ea Sup	838,988
Subregion 35	Basalt Plateau Buon Me Thuat	573,120
Subregion 36	Mdrak Mountain Range	396,339
Subregion 37	Plateau Dak Nong and Dak Min	385,342
Subregion 38	Chu Ang Sin Mountain and Da Lat mountainous plateau	744,877
Subregion 39	Plateau Di Linh and Bao Loc	389,852
VII. Southeast		2,768,152
Subregion 40	Low mountain of Southeast region	1,136,314
Subregion 41	Hilly terrain of Southeast region	881,050
Subregion 42	Southeast plain	594,852
Subregion 43	Southeast coastal mangrove forest	150,731
Subregion 44	Con Dao	5,206
VIII. Southwest		3,982,679
Subregion 45	Mekong Delta	3,696,309
Subregion 46	Mangrove forests of Southwest	230,349
Subregion 47	Southwest Island	56,020

6.2 Forest ecological region database development

The database table are developed on the basis of both theoretical lesson learnt from all activities and desk study findings and experiences from Vietnam's leading experts as well as from the research group specialized in climate, hydrology, geology - geomorphology, soil - site and flora. Due to limited time and budget constraints for field surveys and verification, the forest ecological stratification is apparently subjective and incomprehensive.

Data on climate, topography, geomorphology, typical soil and forest types were developed for each ecoregion and sub-ecoregion. The research team shall use dedicated software WOLDCLIM to process the climate information collected from 40 meteorology stations in

Vietnam. The analysis results of climate characteristics are shown on the maps of temperature, rainfall and humidity indicators in [Annex 3](#).

Table 9 shows a summary of characteristics of forest ecological regions and subregions. The detailed statistical data on forest ecological stratification characteristics including climate, hydrology; geology, geomorphology; soil condition and forest vegetation detailed in [Annex 4](#).

Table 10. Summary of characteristics of forest ecological regions and sub-regions

ZONE Region	Subregion	Boundary	Characteristics of criteria	
A. THE NORTH				
I. Northwest Dien Bien Lai Chau Son La, Hoa Binh	TV1. Da river upstream	Dien Bien, Lai Chau	Climate	T _{year} : 16-22°C; R _{year} 1100-2800mm
			Topography, geomorphology	Mountains at the mean height of 1000-1500m
			Major soil grouping/sub- group	Alisols/Leptosols
			Major forest types /sub-type	Mixed closed humid and high mountainous sub- tropical evergreen humid forests/ coniferous forests + mixed broad-leaved forests, coniferous forests/ bamboo forests + mixed timber and bamboo forests
	TV2. Ma river upstream	Sông Ma district, Son la	Climate	T _{year} : 16-22°C; R _{year} 1100-2800mm
			Topography, geomorphology	> 1000m in height
			Major soil grouping/sub- group	Alisols/Leptosols
			Major forest types /sub-type	Mixed closed and broad- leavedhumid and tropical evergreen humid forests/mixed semi- deciduous forests
	TV3. Son La - Moc Chau Plateau	Son la, Moc Chau	Climate	T _{year} : 18-22°C; R _{year} :1400-1600mm
			Topography, geomorphology	500 – 1000m
			Major soil grouping/sub- group	Acrisols/Alisols/Leptosol s

ZONE Region	Subregion	Boundary	Characteristics of criteria	
	TV4. Da River Valley	Lowland districts in Hoa Binh, Son La	Major forest types /sub-type	Mixed closed humid and medium mountainous tropical evergreen forests / bamboo forests Bamboo forests + mixed timber and bamboo forests
			Climate	T _{year} : 20-23 °C; R _{year} :1100-2200mm
			Topography, geomorphology	Lowland, valleys
			Major soil grouping/sub-group	Ferralsols/Alisols
			Major forest types /sub-type	Mixed closed humid and low mountainous tropical evergreen forests/ mixed closed limestone mountainous/valley forests/ Bamboo forests + mixed timber and bamboo forests
	TV5. Hoang Lien Son mountain Range	Lao Cai, Lai Chau	Climate	T _{year} : 11-23°C; R _{year} : 1600-3500 mm
			Topography, geomorphology	High mountains >1500m
			Major soil grouping/sub-group	Calcisols/Ferralsols
			Major forest types /sub-type	Mixed closed forests on top of limestone mountains and valleys/ Bamboo forests + mixed timber and bamboo forests
			Major forest types /sub-type	Mixed closed and humid evergreen humid forests/ Bamboo forests + mixed timber and bamboo forests
	TV6. Ninh Binh and Hoa Binh hilly terrain	Lowland districts	Climate	T _{year} : 22-24°C; R _{year} :1600-2200 mm
			Topography, geomorphology	Low mountains
			Major soil grouping/sub-group	Acrisols/Ferralsols/Leptosols
			Major forest types /sub-type	Mixed closed and humid evergreen humid forests/ Bamboo forests + mixed timber and bamboo forests

ZONE Region	Subregion	Boundary	Characteristics of criteria	
II North-east Lao cai, Yen Bai, Ha Giang, Tuyen Quang, Phu Tho, Vinh Phuc, Cao Bang, Lang Son, Bac Can, Thái Nguyên, Quảng Ninh, Bac Giang	TV7. Red River and Chay River Valleys	Lao Cai, Yen Bai	Climate	T _{year} : 22-24°C; R _{year} :1600-2000 mm
			Topography, geomorphology	300 – 700m
			Major soil grouping/sub-group	Acrisols/Ferralsols
			Major forest types /sub-type	Mixed closed and humid evergreen humid forests / Bamboo forests + mixed timber and bamboo forests
	TV8. Medium high mountain Hoang Su Phi	Hoang Su Phi – Ha Giang	Climate	T _{year} : 16-23°C; R _{year} : 1400-1800 mm
			Topography, geomorphology	High mountain > 700m
			Major soil grouping/sub-group	Alisols/Ferralsols
			Major forest types /sub-type	Coniferous forests + mixed and broad leaved forests, coniferous forests
	TV9. Lo and Gam Rivers upstream	Gam River, Lo river upstream, Putaca Mountain Block	Climate	T _{year} :21-23°C; R _{year} :1800-4500 mm
			Topography, geomorphology	High mountain > more than 1000m
			Major soil grouping/sub-group	Alisols/Ferralsols
			Major forest types /sub-type	Mixed closed humid and high mountainous sub-tropical evergreen humid forests/ coniferous forests + mixed broad-leaved forests, coniferous forests/ bamboo forests + mixed timber and bamboo forests
	TV10. Low Mountains Bao Lac, Ba Be	Bao Lac, Ba Be	Climate	T _{year} : 15-22°C; R _{year} :1200-1600 mm
			Topography, geomorphology	>700m
			Major soil grouping/sub-group	Calcisols/Ferralsols

ZONE Region	Subregion	Boundary	Characteristics of criteria	
			Major forest types /sub-type	Mixed closed forests on limestone mountains
	TV11. Limestone Mountain Dong Van	Dong van	Climate	T _{year} : 15-22°C; R _{year} :1200-1600 mm
			Topography, geomorphology	> 700m
			Major soil grouping/sub-group	Calcisols/Ferralsols
			Major forest types /sub-type	Mixed closed evergreen humid forests on limestone mountains and valleys/bamboo forests + mixed timber and bamboo forests
	TV12. Midland including Phu Tho, Thai Nguyen, Vinh Phuc and Bac Giang	Phu Tho, Vinh Phuc, Thai Nguyen, Bac Giang	Climate	T _{year} : 23-24°C; R _{year} :1400-1600 mm
			Topography, geomorphology	100 – 300m
			Major soil grouping/sub-group	Calcisols/Ferralsols
			Major forest types /sub-type	Mixed closed forests on limestone mountains and valleys/closed mixed evergreen humid forests
	TV13. Limestone Mountain Bac Son	Bac Son, Lang Son	Climate	T _{year} : 20-22°C; R _{year} :1400-1600 mm
			Topography, geomorphology	More than 700m
			Major soil grouping/sub-group	Calcisols/Ferralsols
			Major forest types /sub-type	Mixed closed forests on limestone mountains/valleys and mixed closed and humid evergreen humid forests
	TV14. Low Mountains Cao Bang, Lang Son and Quang Ninh	Dong Trieu, Lang Son, Trung Khanh, That Khe.	Climate	T _{year} : 18-23°C; R _{year} :1100-1800 mm
			Topography, geomorphology	300m – 700m
			Major soil grouping/sub-group	Acrisols/Ferralsols/Alisols

ZONE Region	Subregion	Boundary	Characteristics of criteria	
	TV15. Northeast coastal mangroves	Coastal districts in Quang Ninh	Major forest types /sub-type	Mixed closed and humid evergreen forests/Bamboo forests + mixed timber and bamboo forests
			Climate	T _{year} : 22-23°C; R _{year} :2000-2800 mm
			Topography, geomorphology	Lowland
			Major soil grouping/sub-group	Solochats/Gleysols
			Major forest types /sub-type	Mangrove forest
	TV16. Northeast Island	Bach Long Vi, Van Don, Co To and Ke Bao	Climate	T _{year} : 23-24°C; R _{year} :1100-1600 mm
			Topography, geomorphology	Lowland
			Major soil grouping/sub-group	Ferralsols/Solochats/Gleysols
			Major forest types /sub-type	Mixed closed humid and low mountainous tropical evergreen humid forests/Mangrove forests
	III. Red river Delta: Hai Phong, Hai Duong, Bac Ninh, Hung Yen, Ha Noi, Thai Binh, Nam Dinh, Ha Nam, Ninh Binh	9 provinces	Climate	T _{year} : 23-24°C; R _{year} :1500-1800 mm
			Topography, geomorphology	Lowland
			Major soil grouping/sub-group	Fluvisol/Gleysols/Acrisols
			Major forest types /sub-type	Plantations
		4 coastal provinces: Hai Phong, Thái Bình, Nam Định, Ninh Bình.	Climate	T _{year} : 23-24°C; R _{year} :1600-1800 mm
			Topography, geomorphology	Lowland
			Major soil grouping/sub-group	Solochats/Gleysols
			Major forest types /sub-type	Mangrove forests
IV. North Central	TV19. Muong Xen	Ky Son, Tuong	Climate	T _{year} : 19-24°C;R _{year} :1400-3000 mm

ZONE Region	Subregion	Boundary	Characteristics of criteria	
Region Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue		Duong - Nghe An	Topography, geomorphology	300 – 700m
			Major soil grouping/sub-group	Acrisols/Ferralsols/Leptosols
			Major forest types /sub-type	Closed mixed and broad-leaved tropical humid forests with sub-types: lowland, <500m; lowland, Dipterocarp dominance
	TV20. Mountainous Area to the west of Thanh Hoa, Nghe An and Ha Tinh provinces	Western mountains : 3 provinces	Climate	T _{year} : 18-23°C; R _{year} : 1100-1400 mm
			Topography, geomorphology	> 700m
			Major soil grouping/sub-group	Ferralsols/Alisols/Leptosols
			Major forest types /sub-type	Mixed closed humid and medium mountainous tropical evergreen forests / bamboo forests Bamboo forests + mixed timber and bamboo forests
	TV21. North Central hilly terrain	6 central provinces	Climate	T _{year} : 22-24°C; R _{year} : 1600-4000 mm
			Topography, geomorphology	Low and medium mountains
			Major soil grouping/sub-group	Acrisols/Ferralsols/Leptosols
			Major forest types /sub-type	Mixed closed humid and low mountainous evergreen tropical humid forests/Bamboo forests + mixed timber and bamboo forests/Plantations
	TV22. Delta and coastal sandy dunes of the North Central Region	6 provinces	Climate	T _{year} : 23-25°C; R _{year} :1600-3000 mm
			Topography, geomorphology	Lowland
			Major soil grouping/sub-group	Fluvisol/Acrisols/Gleysols
			Major forest types /sub-type	Plantations

ZONE Region	Subregion	Boundary	Characteristics of criteria	
	TV23. Limestone Mountain Phong Nha – Ke Bang	Phong Nha – Ke Bang	Climate	T _{year} : 20-22°C; R _{year} :2000-3500 mm
			Topography, geomorphology	Medium mountains
			Major soil grouping/sub-group	Calcisols/Ferralsols
			Major forest types /sub-type	Mixed closed forests on limestone mountains and valleys/Mixed closed and low mountainous tropical evergreen humid forests
	TV24. The mountain range to the West of Binh Tri Thien	3 provinces Quang Binh, Quang Tri, Thua Thien Hue	Climate	T _{year} : 18-23°C; R _{year} :1100-1400 mm
			Topography, geomorphology	>700m
			Major soil grouping/sub-group	Alisols/Ferralsol
			Major forest types /sub-type	Mixed closed sub-tropical evergreen humid forests/bamboo forests on high mountains/bamboo forests + mixed timber and bamboo forests.
B. THE SOUTH				
V. South coastal line: Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa, Ninh Thuan, Binh Thuan	TV25. The Mountain Range to the west of Quang Nam and Quang Ngai	The West of Quang Nam, Quang Ngai	Climate	T _{year} : 19-22°C; R _{year} :2800-4000 mm
			Topography, geomorphology	> 700m
			Major soil grouping/sub-group	Alisols/Ferralsol
			Major forest types /sub-type	Mixed closed and evergreen sub-tropical humid forests on high mountains/Bamboo forests + mixed timber and bamboo forests
	TV26. Hilly terrain of the South Central Region	Dọc thềm gò đồi trung du 7 tỉnh	Climate	T _{year} : 23-26°C; R _{year} :1600-3000 mm
			Topography, geomorphology	Low mountains

ZONE Region	Subregion	Boundary	Characteristics of criteria	
			Major soil grouping/sub-group	Acrisols/Ferralsols/Leptosols
			Major forest types /sub-type	Mixed closed tropical evergreen humid forests on low mountains/Plantations.
	TV27. The delta and coastal sandy dunes of the South Central Region	Coastal provinces	Climate	T _{year} : 26-27°C; R _{year} :1300-2800 mm
			Topography, geomorphology	Lowland
			Major soil grouping/sub-group	Arenosols/Gleysols/Solochats
			Major forest types /sub-type	Plantations
	TV28. Hoang Sa, Truong Sa	Khanh Hoa	Climate	T _{year} : 26-27°C; R _{year} : 700-1400 mm (Phan Rang: R _{year} (1958 - 1993): 693mm)
			Topography, geomorphology	Lowland
			Major soil grouping/sub-group	Haplic lixisols/Chromic lixisols
			Major forest types /sub-type	Popular vegetation layers are savanna and dry shrubs characterized by dry-resistant plants.
	TV29. Extreme dry subregion of the South Central Region	Phan Rang-Phan Ri (Ninh Thuan, Binh Thuan)	Climate	T _{year} : 26-27°C; R _{year} :1200-2400 mm; drought area
			Topography, geomorphology	Flats
			Major soil grouping/sub-group	Luvisols/Alisols
			Major forest types /sub-type	Diptercarp dominant and thin forests (Dry forests)/semi-deciduous closed mixed forests
VI. Highland Kon Tum, Gia Lai, Dak Lak, Dak Nong,	TV30. Ngoc Linh Mountain Range	Khối núi Ngoc Linh.	Climate	T _{year} : 17-22°C; R _{year} :2200-4000 mm
			Topography, geomorphology	High mountain > 1,000m

ZONE Region	Subregion	Boundary	Characteristics of criteria	
Lâm Đồng			Major soil grouping/sub-group	Alisols/Ferralsols/Leptosols
			Major forest types /sub-type	Closed mixed evergreen sub-tropical humid forests on high mountains/semi-deciduous closed and mixed forests
	TV31. Sa Thay low Mountain Range	Sa Thay, North of the Central Highland	Climate	T _{year} : 20-26°C; R _{year} :1600-2000 mm
			Topography, geomorphology	Low mountains
			Major soil grouping/sub-group	Ferralsols/Acrisols/Leptosols
			Major forest types /sub-type	Lowland evergreen closed and mixed tropical humid forests/bamboo forests + mixed timber and bamboo forests
	TV32. Plateau basalt Pleiku, Kon Ha Nung	Kon Ha Nung, Pleiku, An Khê	Climate	T _{year} : 20-24°C; R _{year} :1800-2200 mm
			Topography, geomorphology	Highland
			Major soil grouping/sub-group	Ferralsols/Acrisols
			Major forest types /sub-type	Lowland evergreen closed and mixed tropical humid forests / bamboo forests + mixed timber and bamboo forests
	TV33. An Khe Low Mountain Range		Climate	T _{year} : 25-27°C; R _{year} :1200-1800 mm
			Topography, geomorphology	600-700m
			Major soil grouping/sub-group	Acrisols/Ferralsols/Gleysols
			Major forest types /sub-type	Diptercarp dominant and thin forests (Dry forests)/bamboo forests + mixed timber and bamboo forests

ZONE Region	Subregion	Boundary	Characteristics of criteria	
	TV34. Peneplains Cheo Reo, Phu Bon and Ea Sup	Cheo Reo, Phu Bon, Kon Chro- Chu Se- Easup	Climate	T _{year} : 23-25°C; R _{year} :1500-2000 mm
			Topography, geomorphology	Lowland
			Major soil grouping/sub- group	Acrisols/Ferralsols/Gleys ols
			Major forest types /sub-type	Diptercarp dominant and thin forests (Dry forests)/ bamboo forests + mixed timber and bamboo forests
	TV35 Buon Me Thuat Basalt Pleateau	Buon Ho – Buon Me Thuat	Climate	T _{year} : 23-25°C; R _{year} :1600-2000 mm
			Topography, geomorphology	Pleateau
			Major soil grouping/sub- group	Ferralsols
			Major forest types /sub-type	Evergreen closed and mixed tropical humid forests on medium mountains
	TV36. M' Drak Mountain Range		Climate	T _{year} : 22-24°C; R _{year} :1600-2600 mm
			Topography, geomorphology	700-800m
			Major soil grouping/sub- group	Acrisols/Ferralsols
			Major forest types /sub-type	Evergreen closed and mixed tropical humid forests on medium mountains/Diptercarp dominant and thin forests (Dry forests)/Coniferous forests+ mixed coniferous and broad-leaved
	TV37. Plateau Dak Nong and Dak Min	Dak Nong, Bao Loc	Climate	T _{year} : 22-24°C; R _{year} :1600-2200 mm
			Topography, geomorphology	Plateau
			Major soil grouping/sub- group	Acrisols/Ferralsols

ZONE Region	Subregion	Boundary	Characteristics of criteria	
	TV38. Chu Ang Sin Mountain and Da Lat mountainous plateau	Chu Yan Sin–Da Lat Mountains	Major forest types /sub-type	Evergreen closed and mixed tropical humid forests on medium mountains/ Dipterocarp dominant and thin forests (Dry forests)/Coniferous forests+ mixed coniferous and broad-leaved
			Climate	T _{year} : 16-25°C; R _{year} :1500-2200 mm
			Topography, geomorphology	> 1000m
			Major soil grouping/sub-group	Alisols/Ferralsols/Leptosols
	TV39 Plateau Di Linh and Bao Loc	Lam Dong	Major forest types /sub-type	Evergreen closed and mixed sub-tropical humid forest on high mountains/Semi-deciduous closed and mixed forests
			Climate	T _{year} : 20-22°C; R _{year} :1500-2800 mm
			Topography, geomorphology	>700m
			Major soil grouping/sub-group	Ferralsols/Acrisols
VII. Southeast Ba Ria-Vung Tau, Dong Nai, Binh Duong, Binh Phuoc, Tay Ninh	TV40. Low mountain of Southeast region	Binh Duong, Binh Phuoc, Tay Ninh	Major forest types /sub-type	Evergreen mixed and closed sub-tropical humid forests on high mountains/Semi-deciduous closed and mixed forests
			Climate	T _{year} : 25-27°C; R _{year} :1800-2800 mm
			Topography, geomorphology	Low mountain
			Major soil grouping/sub-group	Acrisols/Ferralsols

ZONE Region	Subregion	Boundary	Characteristics of criteria	
Ninh, Ho. Ho Chi Minh			Major forest types /sub-type	Evergreen mixed and closed tropical humid forest on low mountains/Diptercarp dominant and thin forests (Dry forests)
	TV41. Hilly terrain of Southeast region	Lowland districts	Climate	T _{year} : 26-27°C; R _{year} :1600-2200 mm
			Topography, geomorphology	Lowland
			Major soil grouping/sub-group	Fluvisol/Acrisols/Gleysols
			Major forest types /sub-type	Plantations
	TV42. Southeast Plain	Southeast	Climate	T _{year} : 26-27°C; R _{year} : 1400-2000
			Topography, geomorphology	Plain (< 10m)
			Major soil grouping/sub-group	Fluvisol/Gleysols
			Major forest types /sub-type	Lowland evergreen closed broad-leaved Diptercarp dominant forests/Plantations
	TV43. Southeast coastal mangrove forest	Coastal area of HCM city – Ba Ria Vung Tau	Climate	T _{year} : 26-27°C;R _{year} :1400-2000 mm
			Topography, geomorphology	Coastal line
			Major soil grouping/sub-group	Solochats/Hitosols
			Major forest types /sub-type	Mangrove forests
	TV44. Con dao island	Con Dao	Climate	T _{year} : 26-27 °C; R _{year} :1400-1800 mm
			Topography, geomorphology	Island
			Major soil grouping/sub-group	Acrisols/Ferralsols/Solochats

ZONE Region	Subregion	Boundary	Characteristics of criteria	
			Major forest types /sub-type	Evergreen closed and mixed tropical humid forests on low mountains/mangrove forests
VIII. Southwest Long An, Ben Tre, Dong Thap, Soc Trang, Vinh Long, Can Tho, Hau Giang, Tien Giang, Bac Lieu, Ca Mau, Kien Giang, Tra Vinh	TV45. Mekong Delta	Delta	Climate	T _{year} : 26-27°C; R _{year} :1400-1900 mm
			Topography, geomorphology	Lowland (<10m)
			Major soil grouping/sub-group	Fluvisol/Gleysols/Histosols
			Major forest types /sub-type	Plantation/Melaleuca forests
	TV46. Mangrove forests of Southwest	Ben Tre, Tra Vinh, Bac Lieu, Ca Mau, Kien Giang	Climate	T _{year} : 27-28 °C; R _{year} :2000-3500mm
			Topography, geomorphology	Coastal line
			Major soil grouping/sub-group	Solochats/Histosols/Gleysols
			Major forest types /sub-type	Mangrove forests
	TV47. Southwest Islands	Phu Quoc	Climate	T _{year} : 26-27 °C; R _{year} :1400-1900 mm
			Topography, geomorphology	Island
			Major soil grouping/sub-group	Acrisols/Ferralsols/Solochats
			Major forest types /sub-type	Evergreen closed and mixed humid forests/mangrove forests

Remark: T_{year} is the mean annual temperature (°C); R_{year} is the mean annual rainfall (mm).

6.3 Forest ecological stratification map

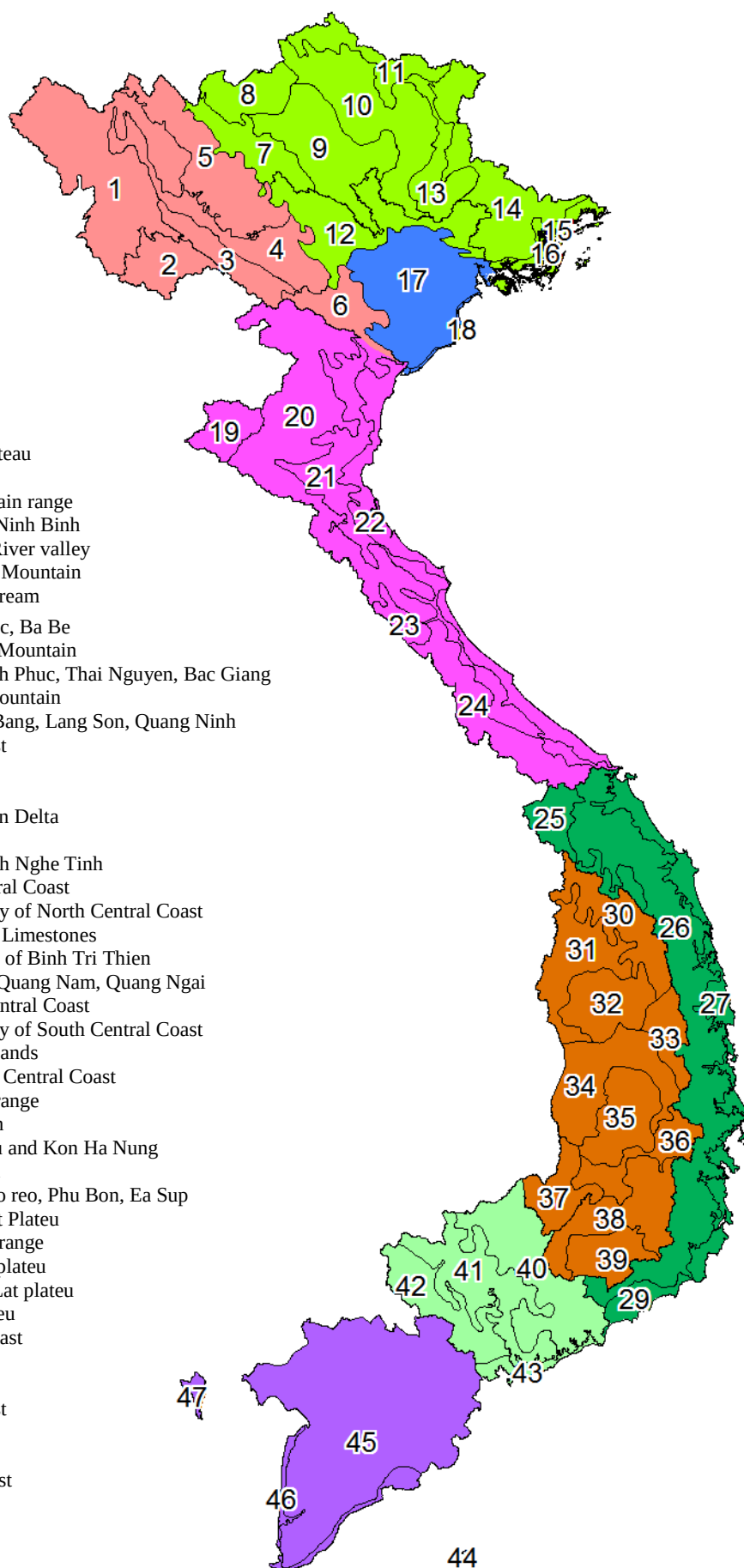
Based on forest ecological stratification criteria and zoning methods as mentioned above, the forest ecological stratification map is developed at the scale of 1/1.000.000 for nationwide and 1/250.000 for 8 ecoregions as identified above. These maps include layers of information on climate, topography, geomorphology and soil. Forest ecological stratification maps for different regions are to be presented in **Annexes 5, 6, 7, 8, 9, 10, 11 and 12.**

Regions

- North West
- North East
- Northern Delta
- Middle North
- Middle South
- Central Highland
- South East
- South East

Sub-regions

- 1: Da river upstream
- 2: Ma river upstream
- 3: Son La - Moc Chau plateau
- 4: Da river valley
- 5: Hoang Lien Son mountain range
- 6: Hill land of Hoa Binh, Ninh Binh
- 7: Hong River and Chay River valley
- 8: Hoang Su Phi medium Mountain
- 9: Lo and Gam rivers upstream
- 10: Low mountain Bao Lac, Ba Be
- 11: Dong Van Limestone Mountain
- 12: Hillland Phu Tho, Vinh Phuc, Thai Nguyen, Bac Giang
- 13: Bac Son Limestone Mountain
- 14: Low hill land of Cao Bang, Lang Son, Quang Ninh
- 15: Mangrove of Northeast
- 16: Northeast Islands
- 17: Northern Delta
- 18: Mangroves of Northern Delta
- 19: Muong Xen
- 20: West moutain of Thanh Nghe Tinh
- 21: Hilland of North Central Coast
- 22: Delta and coastal sandy of North Central Coast
- 23: Phong Nha - Ke Bang Limestones
- 24: West Mountain Range of Binh Tri Thien
- 25: Western Mountain of Quang Nam, Quang Ngai
- 26: Hilly area of South Central Coast
- 27: Delta and coastal sandy of South Central Coast
- 28: Paracel and Spratly Islands
- 29: Drought area of South Central Coast
- 30: Ngoc Linh Mountain range
- 31: Sa Thay low Mountain
- 32: Basalt Plateau of Pleiku and Kon Ha Nung
- 33: An Khe low Mountain
- 34: Peneplain area of Cheo reo, Phu Bon, Ea Sup
- 35: Buon Ma Thuot Basalt Plateau
- 36: Man Drack Mountain range
- 37: Dak Nong - Dak Min plateau
- 38: Chu Ang Sin and Da Lat plateau
- 39: Di Linh, Bao Loc plateau
- 40: Low Mountain Southeast
- 41: Hillland of Southeast
- 42: Southeast Delta
- 43: Mangrove of Southeast
- 44: Con Dao Islands
- 45: Mekong Delta
- 46: Mangrove of Southwest
- 47: Southwest Islands



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6.4 Discussion and recommendations

- The baseline and secondary data collected from existing theoretical studies and experiences is very abundant and diversified. However, due to limited time and resources, there is an absence of verification.
- It is the first time since the forest ecological stratification has been seriously and quite thoroughly considered. The forest ecological stratification is based on climate, hydrology, geology and geomorphology; soil and forest ecosystems in Vietnam. However, the authors feel regretful not to conduct further comprehensive in-depth research with aims to meet other practical purposes such as succession in forest sere, forest rehabilitation etc..). This research fails to study current and potential productivity of forest ecological sub-regions.
- Ecological sub-region is a basic unit because of its relative homogeneity of climate, geology, geomorphology and soil conditions. It also reflects major characteristics of forest ecosystems. This is a basis for calculating biomass and carbon stocks and makes forest development planning in Vietnam.
- The development of REL/RL and implementation of MRV for REDD activities in Vietnam should consider cost effectiveness because the accuracy of REL/RL and MRV depend on homogenous forest vegetation type and its potential productivity. Therefore, it is strongly recommended to take into account the cost-benefits analysis when deciding to use a certain stratification hierarchy for REL/RL development. For national scale, the use of 8 ecological regions for development of REL/RL and MRV is suggested. However, for sub-national the development of REL/RL and MRV should be implemented following the ecological-subregions.
- Due to limited resources, database on ecological stratification is not consistent in terms of time and sources of provisions. And this database is not verified. Therefore, users are supposed to take note of this disadvantage since this is the first study on this issue.

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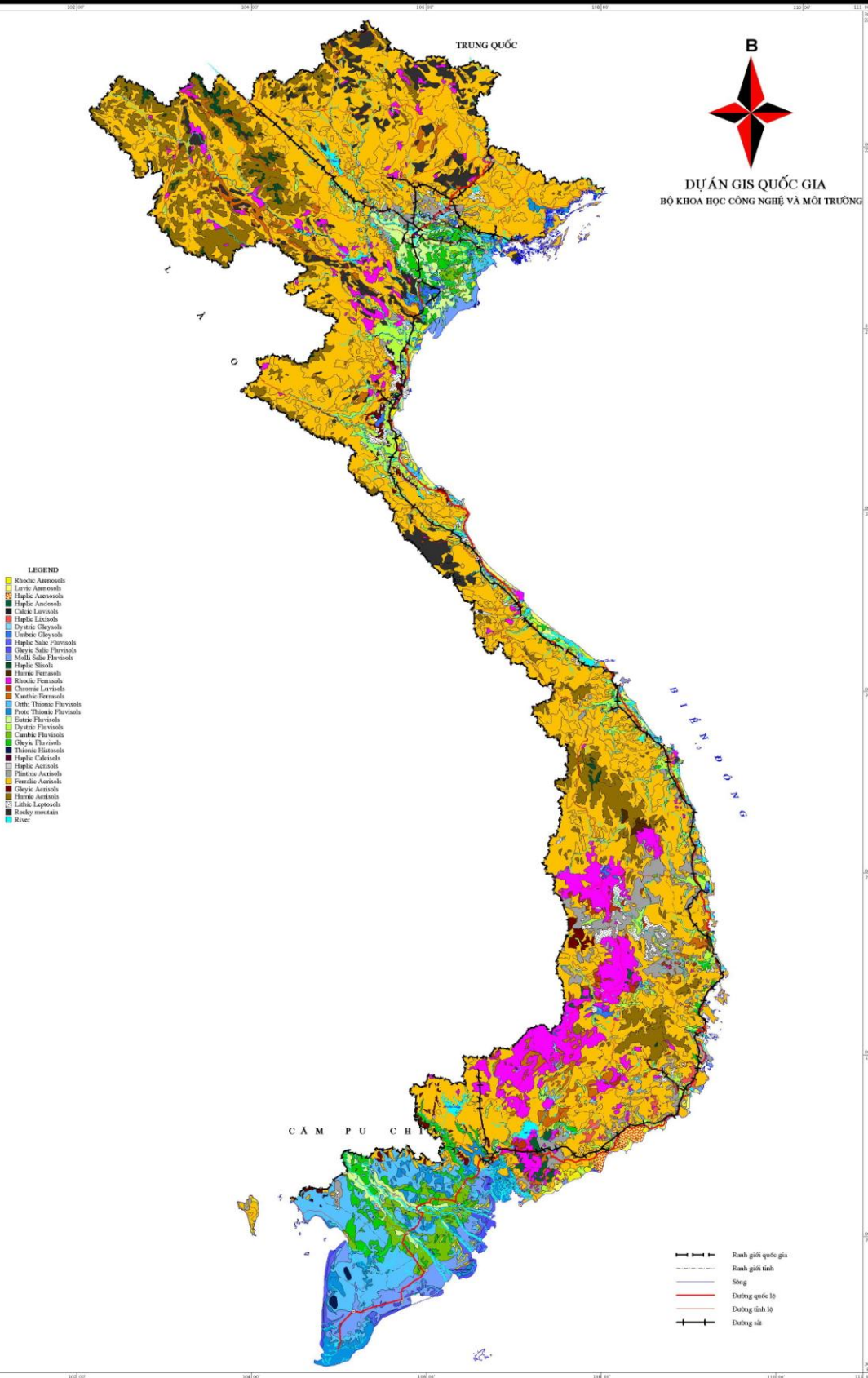
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Annex 1. Soil names according to Vietnam and FAO/UNESCO

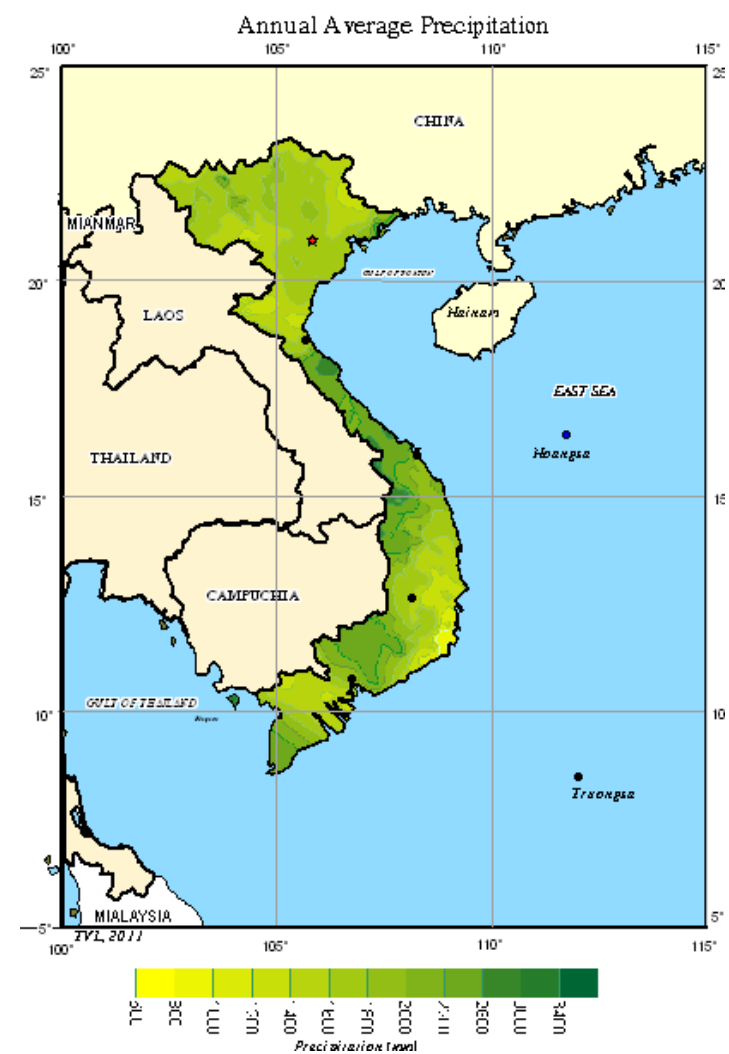
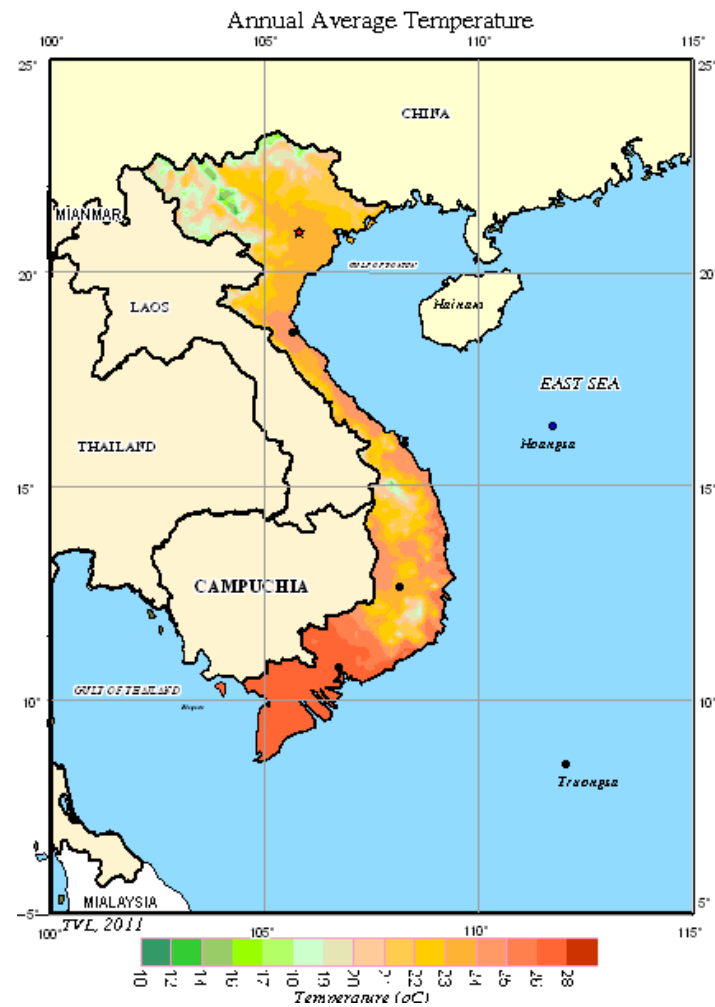
No.	Code	Vietnamese name	Symbol	Đất name FAO – UNESCO
I	C	Đất cát	AR	Arenosols
1	Cc	Đất cồn cát trắng vàng	ARl	Luvic arenosols
2	Cđ	Đất cồn cát đỏ	ARr	Rhodic arenosols
3	C	Đất cát điển hình	ARh	Haplic arenosols
4	Cb	Đất cát mới biến đổi	ARb	Cambic arenosols
5	Co	Đất cát potzon	ARa	Albic arenosols
6	Cg	Đất cát glây	ARg	Gleyic arenosols
7	Cf	Đất cát feralit	ARo	Feralit arenosols
II	M	Đất mặn	SC	Solonchaks
8	Mm	Đất mặn sú vẹt được	SCg	Gley solonchaks
9	Mn	Đất mặn nhiều	SCh	Haplic solonchaks
10	M	Đất mặn trung bình và ít	SCm	Mollic solonchaks
III	S	Đất phèn	FLt	Thionic fluvisols
11	p	Đất phèn tiềm tàng	GLt	Thionic gleysols
12	Sj	Đất phèn hoạt động	GLtp GLto	Protothionicgleysols Orthithionicfluvisols
IV	P	Đất phù sa	FL	Fluvisols
13	P	Đất phù sa trung tính ít chua	FLe	Eutric fluvisols
14	Pc	Đất phù sa chua	FLd	Distric fluvisols
15	Pg	Đất phù sa glây	FLg	Gleyic fluvisols
16	Pu	Đất phù sa mùn	FLu	Umbric fluvisols
17	Pb	Đất phù sa có đốm rỉ	FLb	Cambic fluvisols
V	GL	Đất glây	GL	Gleysols
18	GL	Đất glây trung tính ít chua	GLe	Eutric gleysols
19	GLc	Đất glây chua	GLd	Distric gleysols
20	GLu	Đất lầy	GLu	Umbric gleysols
VI	T	Đất than bùn	HS	Histosols
21	T	Đất than bùn	HSf	Fibric histosols
22	Ts	Đất than bùn tiềm tàng	HSt	Thionic histosols
VII	MK	Đất mặn kiềm	SN	Solonetz
23	MK	Đất mặn kiềm	SNh	Haplic solonetz
24	MKg	Đất mặn kiềm glây	SNg	Gleyic solonetz
VIII	CM	Đất mới biến đổi	CM	Cambisols
25	CM	Đất mới biến đổi ít chua	CMe	Eutric cambisols
26	CMc	Đất mới biến đổi chua	CMd	Diystic cambisols
IX	RK	Đất đá bột	AN	Andosols
27	RK	Đất đá bột	ANh	Haplic andosols
28	RKh	Đất đá bột mùn	ANm	Mollic andosols

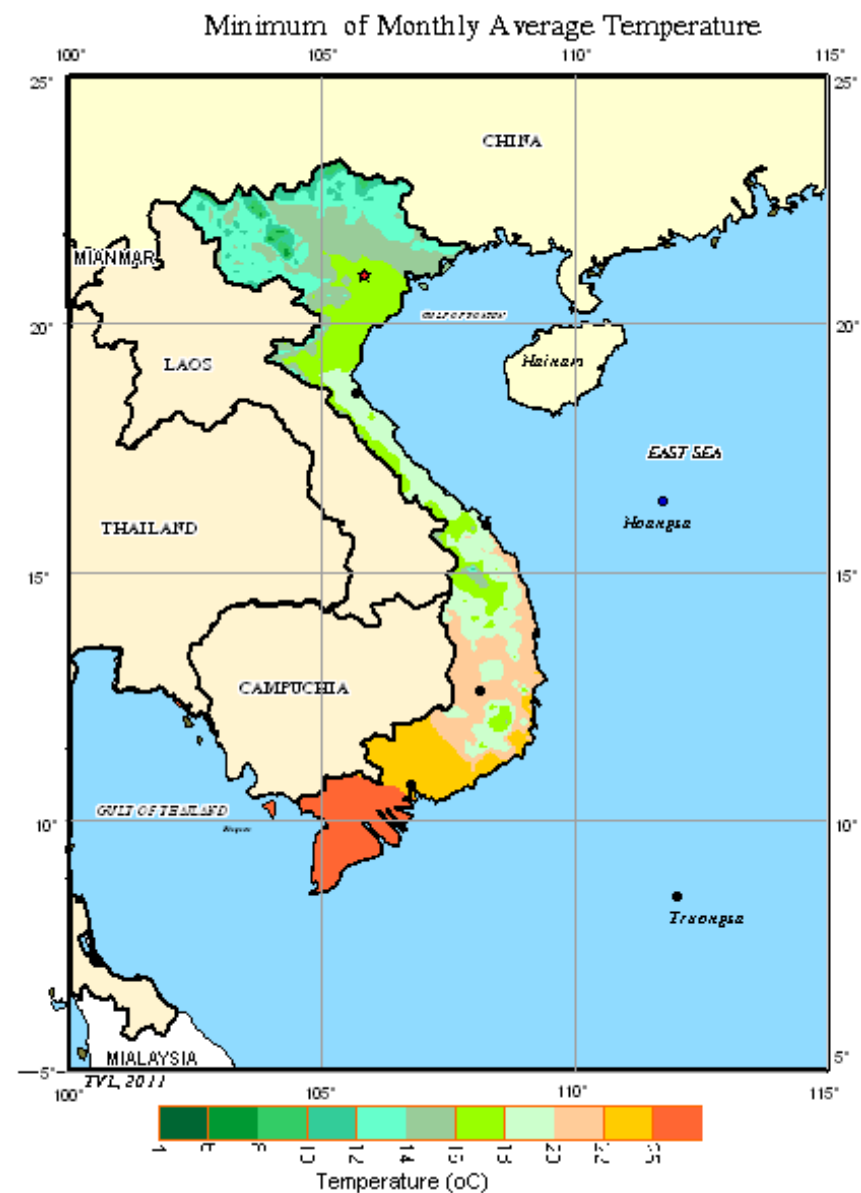
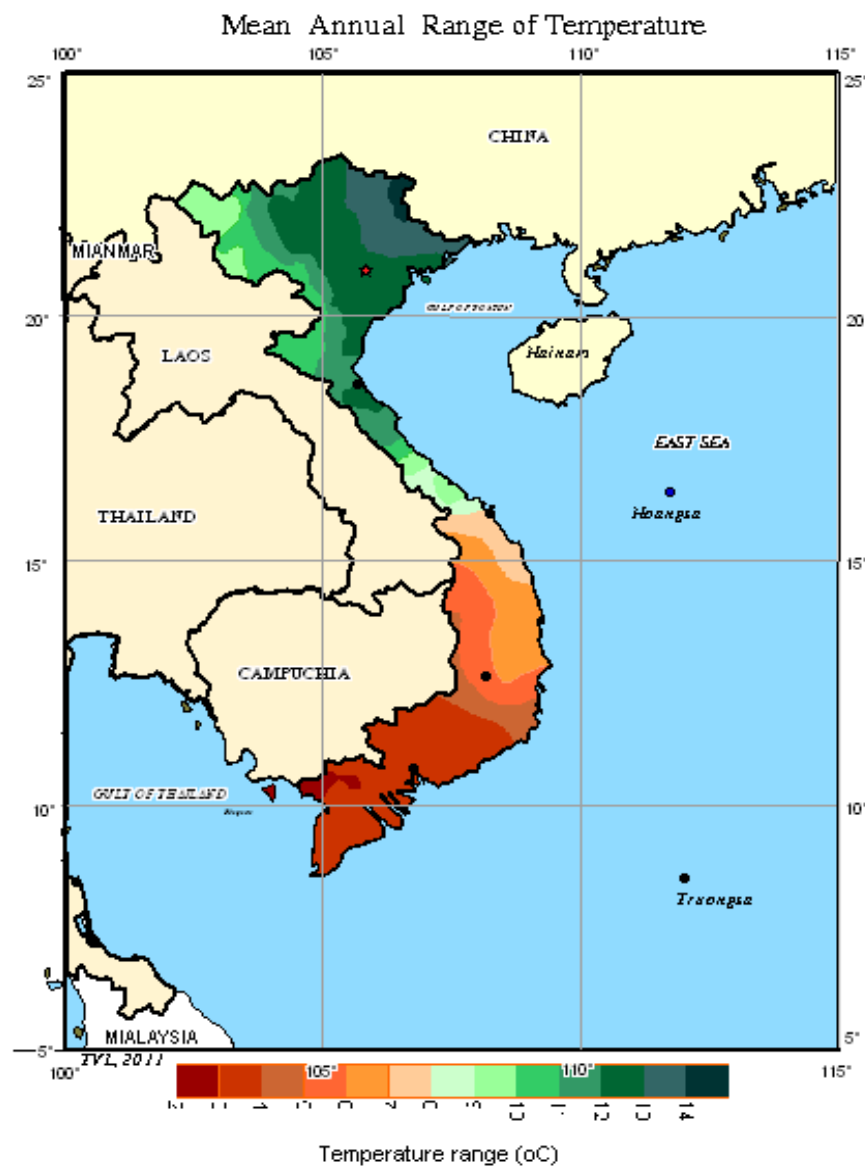
No.	Code	Vietnamese name	Symbol	Đất name FAO – UNESCO
X	R	Đất đen	LV	Luvisols
29	Rf	Đất đen tầng kết von dày	LVf	Ferric luvisols
30	Rg	Đất đen glây	LVg	Gleyic luvisols
31	Rv	Đất đen cacbonat	LVk	Calcic luvisols
32	Ru	Đất nâu thâm bazan	LVx	Chromic luvisols
33	Rq	Đất đen tầng mỏng	LVq	Lithic luvisols
XI	N	Đất nứt nẻ	VR	Vertisols
34	Ne	Đất nứt nẻ trung tính ít chua	VRe	Eutric vertisols
35	Nd	Đất nứt nẻ chua	VRd	Dystric vertisols
XII	XK	Đất nâu	LX	Lixisols
36	XK	Đất nâu vàng bán khô hạn	LXh	Haplic lixisols
37	XKd	Đất đỏ vàng bán khô hạn	LXx	Chromic lixisols
38	XKh	Đất nâu vàng vùng khác	LVh	Haplic lixisols
XIII	V	Đất tích vôi	CL	Calcisols
39	V	Đất vàng tích vôi	CLh	Haplic calcisols
40	Vu	Đất nâu thâm tích vôi	CLl	Luvic calcisols
XIV	L	Đất có tầng sét loang lỗ	PT	Plinthosols
41	Lc	Đất sét loang lỗ chua	PTd	Dystric plinthosols
42	La	Đất sét loang lỗ rửa trôi mạnh	PTa	Albic plinthosols
43	Lu	Đất sét loang lỗ giàu mùn	PTu	Humic plinthosols
XV	O	Đất podzolic	PD	Podzoluvisols
44	Oc	Đất podzolic chua	PDd	Dystricpodzoluvisols
45	Og	Đất podzolic glây	PDg	Gleyic podzoluvisols
XVI	X	Đất xám	AC	Acrisols
46	X	Đất xám bạc màu	ACh	Haplic acrisols
47	Xl	Đất xám loang lỗ	ACp	Plinthic acrisols
48	Xg	Đất xám glây	ACg	Gleyic acrisols
49	Xf	Đất xám feralit	ACf	Ferralic acrisols
50	Xh	Đất xám mùn trên núi	ACu	Humic acrisols
XVII	B	Đất nâu tím	NT	Nitisols
51	B	Đất nâu tím	NTh	Haplic nitisols
52	Bd	Đất nâu tím đỏ	NTr	Rhodic nitisols
XVIII	F	Đất đỏ	FR	Ferralsols
53	Fd	Đất nâu đỏ	FRe	Rhodic ferralsols
54	Fx	Đất nâu vàng	FRx	Xanthic ferralsols
55	Fl	Đất đỏ vàng sét loang lỗ	FRp	Plinthic ferralsols
56	Fh	Đất mùn vàng đỏ trên núi	FRu	Humic ferralsols
XIX	A	Đất mùn alit núi cao	AL	Alisols
57	A	Đất mùn alit núi cao	ALh	Humic alisols
58	Ag	Đất mùn alit núi cao glây	ALg	Gleyic alisols
59	AT	Đất mùn than bùn núi cao	ALu	Histic alisols
XX	E	Đất XM tro sỏi đá	LP	Leptosols
60	E	Đất xói mòn tro sỏi đá	LPq	Lithic leptosols
XXI	N	Đất nhân tác	AT	Anthrosols
61	N	Đất nhân tác	AT	Anthrosols

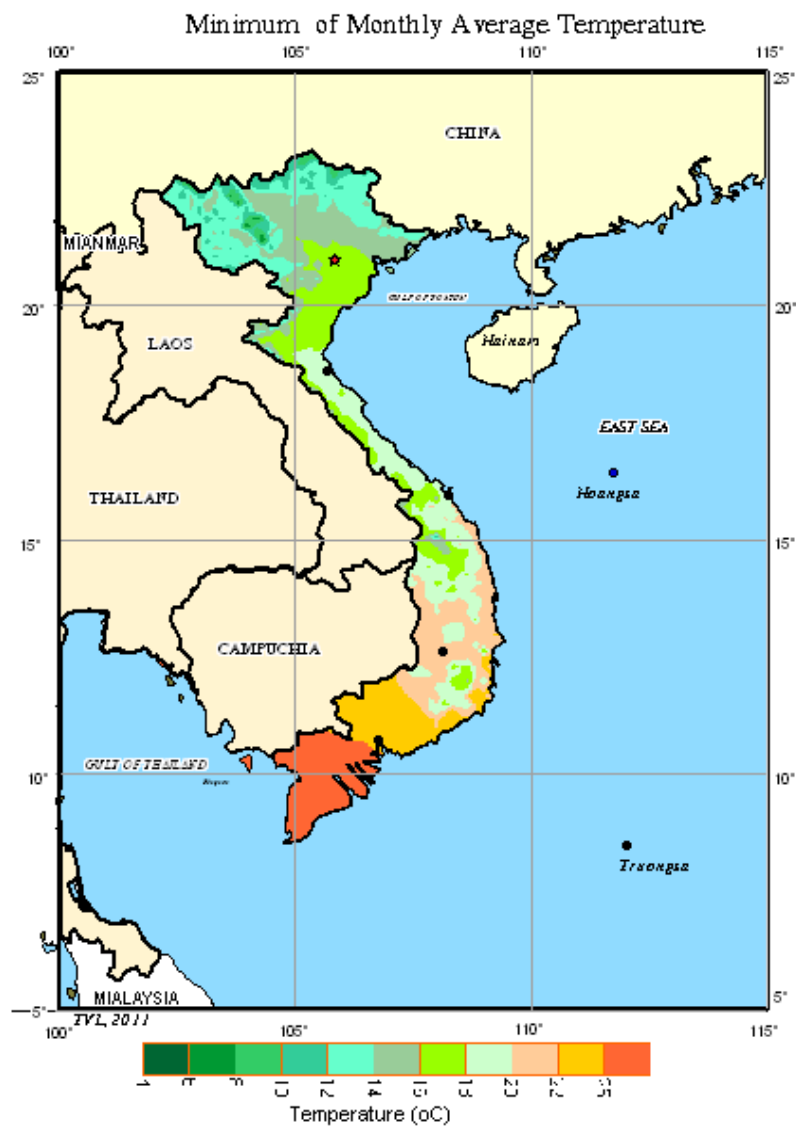
Annex 2. Vietnam's soil map based on FAO/UNESCO



Annex 3. Map of temperature, precipitation and evapotranspiration







Annex 4. Description of forest ecological regions and sub-regions characteristics

Sub-region	Indicator	Major characteristics
I. North west	Climate	The climate is lowly impacted by denatured sea zone air. It is also early impacted by tropical air from the West and relatively dramatically tropical sea air from the East. Due to the strongly fragmented topography and quite high elevation, there still exist cold winter and highly-divided climate. T_{year} fluctuates 11-23°C; BD_{year} : 8-11°C; T_{min} may be lower than 0°C in the North and lower than 5°C in the South, there is possibility of frost and snows in high mountainous areas to the North of Hoang Lien Son Mountain Range. The dry and hot weather early appears in lowland valleys, possibly $T_{\text{max}} > 40^{\circ}\text{C}$, R_{year} fluctuates 1100-3500mm. There are many heavy rainfall centers with R_{year} : 2000-3500mm, however, there are low rainfall areas with R_{year} : 1200-1400mm/year. It is not directly impacted by sea. Climate is much of continental characteristics. The temperature amplitude is large BDT_{day} : 8-13°C. There is a prolonged dry season every year for the period winter and spring. There is no drizzling rain. There is a very cold winter and very cool summer on high elevation belts. Sun radiation is very large. The climate is lowly impacted by many storms and hurricanes.
	Geomorphology	High, medium and low mountain ranges develop on different types of rocks. They are alternately inserted with Da and Ma river valleys, of which is a majority of medium and low mountains. Topography is highly fragmented while the side slope is high
	Soil	There are mainly different types of Acrisols, Humic ferralic acrisols, feralite Rhodic ferralsols and Xanthic ferralsols which are established on the Mica Schist, Shale and Granite. The layer and fertility ranges from medium to good. And they are tend to decrease from the high elevation belt to the low one

Sub-region	Indicator	Major characteristics
	Forest vegetation	Due to fragmented topography and high climate division, forest vegetation of Northwest is much diversified. Major forest types are Evergreen mixed closed and broad leaved humid forests (with sub-types such as lowland evergreen mixed closed and broad leaved humid forests less than 700m; lowland Evergreen mixed closed and broad leaved humid forests in the South, Dipterocarp dominance; hilly, low and medium mountainous evergreen mixed closed and broad leaved humid forests 500 – 1,500m. Semi-deciduous mixed forests; coniferous forests and mixed broad-leaved and coniferous forests, bamboo forests and mixed timber and bamboo forests and all types of plantations are found in these sub-regions. In general, Northwest forests have been strongly impacted. Primitive forests do no longer exist. There exist only human-intervened secondary statuses. Forest volume and yield in the region is quite low (on the average: 80- 245m ³ /ha). Forests in the region play a vital role in watershed protection. The greatest value of forests is environmental services and non-timber forest products
TV 1: Da River upstream	Climate	T _{year} : 16-22°C; R _{year} 1100-2800mm
	Geomorphology	Medium mountainous blocks and low mountains alternately inserted with small valleys, on different rocks, with the average elevation of 1,000m; strongly-fragmented topography, with many mountain tops at more than 2,000m, high slope > 30°C.
	Soil	Ferralic Acrisols, Humic Acrisols and Rhodic Ferralsols on sedimentary acidic rock formed by the alit and feralit process; medium thick layer, quite good soil fertility and humus
	Forest vegetation	Popular forest types include evergreen mixed closed and broad leaved humid forests (with such sub-types as lowland mixed closed and broad leaved humid forests less than 700m; hilly, low and medium mountainous evergreen mixed closed and broad leaved humid forests (500-1500m) and semi-deciduous mixed forests.

Sub-region	Indicator	Major characteristics
		Semi-deciduous mixed forests in this subregion is arising from climate conditions of some lowland areas of Muong La and Thuan Chau districts (Son La); Muong Nhe (Dien Bien) and Muong Te (Lai Chau) mainly due to changes in ecological conditions (mainly soil deck degradation and deterioration). The results have created plant populations in which light-demanding and high drought-resistant species adaptable to harsh weather conditions by means of controlling water evaporation through the deciduous phenomena, for instance, the species such as <i>Liquidamba formosana</i> , <i>Styrax tonkinensis</i> , <i>Dendrocalamus sericeus</i> , <i>Quercus griffithii</i> , <i>Q. serrata</i> , <i>Q. acutissima</i> , <i>Engelhardtia colebrookiana</i> , <i>Carya tonkinensis</i> , <i>Schima wallichiana</i> etc. are dominant species. Average volume is 80-180 m ³ /ha.
TV 2: Ma River upstreams	Climate	T _{year} : 16-22°C; R _{year} 1100-2800mm
	Geomorphology	Low mountains developed on a number of rocks. The terrain of low mountains to be formed on different rocks spreading along to the Northwest – Southeast with the strongly-fragmented terrain, average elevation of more than 1,000m. The central part is quite flat alluvial ground.
	Soil	Ferralic Acrisols, Humic Acrisols, Rhodic Ferralsols on sedimentary acidic rock formed by the alit and feralit process; medium thick layer, quite good soil fertility and humus.
	Forest vegetation	Popular forest types include evergreen mixed closed and broad leaved humid forests (with such sub-types as lowland evergreen mixed closed and broad leaved humid forests less than 700m hilly, low and medium mountainous evergreen mixed closed and broad leaved humid forests (500-1500m) and semi-deciduous mixed forests. Semi-deciduous mixed forests in this subregion is arising from climate conditions of some lowland areas of Muong La and Thuan Chau districts (Son La); Muong Nhe (Dien Bien) and Muong Te (Lai Chau) mainly due to changes in ecological conditions (mainly soil deck degradation and deterioration).

Sub-region	Indicator	Major characteristics
		The results have created plant populations in which light-demanding and high drought-resistant species adaptable to harsh weather conditions by means of controlling water evaporation through the deciduous phenomena, for instance, the species such as <i>Liquidamba formosana</i> , <i>Styrax tonkinensis</i> , <i>Dendrocalamus sericeus</i> , <i>Quercus griffithii</i> , <i>Q. serrata</i> , <i>Q. acutissima</i> , <i>Engelhardtia colebrookiana</i> , <i>Carya tonkinensis</i> , <i>Schima wallichiana</i> etc are dominant species. Average volume is 80-180 m ³ /ha.
TV 3: Son La – Moc Chau	Climate	T _{year} : 18-22°C; R _{year} : 1400-1600mm
	Geomorphology	Limestone plateau inserted between mountains tops on different rocks. The plateau has a direction of Northwest – Southeast at the medium elevation of 600 – 700m.
	Soil	Humic acrisols, Ferralic acrisols, Rhodic ferralsols on degenerated rocks and limestone formed by the feralite and alit processes, thick layer, high humus, high fertility
	Forest vegetation	- Popular forest types are hilly, low and medium mountainous evergreen mixed closed and broad leaved humid forests at the elevation of 500-1500m and coniferous forests, mixed broad-leaved and coniferous forests. - Sub-types including hilly, low and medium mountainous evergreen mixed closed and broad leaved humid forests at the elevation of 500-1500m in this region formed weathered limestone soil, thin soil class with high humus and fast absorbency. Dominant species include <i>Taxotrophis illicifolia</i>, <i>Excentrodendron tonkinense</i>, some <i>Quercus acutissima</i>, <i>Q. serrata</i> species, <i>Carya tonkinensis</i>, <i>C. chinensis</i>, <i>Engelhardtia</i> spp. and some <i>Phoebe</i>, <i>Actinodaphne</i>, <i>Litsea</i> species etc. Accompanied species which are often to be found under the forests include <i>Prunus arborea</i>, <i>Gironiera subaequalis</i>, <i>Chukrasia tabularis</i>, <i>Castanopsis indica</i>, <i>C. chinensis</i>, <i>Mallotus philippinensis</i> etc. Average yield: 100-200 m³/ha.

Sub-region	Indicator	Major characteristics
		- Coniferous forests, mixed broad-leaved and coniferous forests widely distributed on tops of rocky mountains. Apart from broad-leaved forests which are often found such sub-types as hilly, low and medium mountainous evergreen mixed closed and broad leaved humid forests (500-1500m) as mentioned above, under the dominant layers such coniferous species as <i>Keteleeria davidiana</i> , <i>Dacrycarpus imbricatus</i> , <i>Nageia</i> spp., <i>Pinus merkusii</i> are also found... This is a high economic and scientific value ecological system in the sub-region. The average volume is 120-220 m ³ /ha.
TV4: Da river valleys	Climate	T _{year} : 20-23 °C; R _{year} : 1100-2200mm
	Geomorphology	The mountainous terrain is dominant in the North, including route-based topography to the Northwest – Southeast with the absolute elevation of over 2,000m and with many tops; there is a hilly and bowl-formed terrains in the Southeast. The central part is the valley terrains, including alluvial and relatively flat flood-plain benches.
	Soil	Mainly Ferralic Acrisols, Rhodic Ferralsols and wetland formed on sedimentary rocks and acid extravasated rock formed during the feralite process. Quite good soil fertility and high humus.
	Forest vegetation	- Dominant forest types consist of <i>Litsea</i> , <i>Machilus</i> (belonging to family Lauraceae); <i>Lithocarpus</i> , genus <i>Castanopsis</i> (under the family Fagaceae) etc and some other species such as <i>Excentrodendron tonkinense</i> , <i>Taxotrophis illicifolia</i> , <i>Garcinia fagraeoides</i> , <i>Celtis</i> spp.. Commercially-valued species are usually exhaustively harvested; other species including <i>Aglaia</i> spp., <i>Pterospermum</i> spp., <i>Streblus macrophyllus</i> etc. The flora population includes other economic value species such as <i>Markhamia stipulata</i> , <i>Chukrasia tabularis</i> , <i>Streblus macrophyllus</i> , <i>Taxotrophis illicifolia</i> , <i>Streblus tonkinensis</i> . The average volume is 80-150 m ³ /ha. - Different types of plantations consist of major species such as <i>Acacia</i> spp., <i>Eucalyptus</i> spp., <i>Bambusa</i> spp. and some indigenous broad-leaved species. The average volume is 8-12 m ³ /ha/year.
TV 5: Hoang Lien Son Mountain Range	Climate	T _{year} : 11-23 °C; R _{year} : 1600-3500 mm
	Geomorphology	The medium and high mountainous berg terrain is made of different types of rocks, along to the Northwest and Southeast. The elevation is at least 1,500m; there are strongly-fragmented topography, high slope, many tops with the elevation > 2,000m. Fanxipang is the country's highest mountain in Vietnam (3143m).

Sub-region	Indicator	Major characteristics
	Soil	Mainly including Ferralic Acrisols, Humic Acrisols on the degenerated rocks and Acid Extravasated rocks formed during the feralite, alite and humic process, Quite good soil fertility and humus and high erosion
	Forest vegetation	- Evergreen mixed closed and broad leaved humid forests with the 2 sub-types, i.e. evergreen mixed hilly, low and medium mountainous closed and broad leaved humid forests at the elevation of 500-1500m and high mountainous evergreen mixed closed and broad leaved humid forests at over 1500m. + The forest subtype of hilly, low and medium mountainous evergreen mixed closed and broad leaved humid forests at the elevation of 500-1500m has such dominant species such as mountainous <i>Lithocarpus</i> species, <i>Quercus</i> species under the Fagaceae family; <i>Illicium</i> spp under the Illiciaceae family; <i>Eurya</i> species, <i>Camelia</i> and <i>Hartia</i> under the Theaceae family; some <i>Acer</i> species under the Aceraceae family; <i>Alnus nepalensis</i> under the Betulaceae family; <i>Magnolia</i> including <i>Manglietia</i> under the Magnoliaceae family, <i>Diplopanax</i> under the Araliaceae family; <i>Pentaphylax</i> under the Pentaphyllaceae family, <i>Rhodoleia</i> under the Rhodoleiaceae family, etc. or mixed with coniferous species such as <i>Fokienia hodginsii</i> under the Cupressaceae family, <i>Tsuga yunnanensis</i> and <i>Abies delavayi</i> under the Pinaceae family. The vegetation cover is characterized by such dominant species as Ericaceae, mainly including <i>Rhododendron</i> with 6-10 species, <i>Lyonia</i> with 2-3 species, <i>Gaultheria</i> with 2-3 species. + The sub-type of high mountainous evergreen mixed closed and broad leaved humid forests > 1,500m in this region are developing on acidic and thin soil class. There is fog all year round and low temperature, and rainfall ranging between 1800-3200mm/year. This forest sub-type is formed by low timber trees including species of the following family as Ericaceae, Illiciaceae, Rosaceae, Theaceae, v.v mixed with <i>Tsuga yunnanensis</i>, <i>Abies delavayi</i> and some bamboo species under the <i>Arundinaria</i> family, and <i>A. amabilis</i> = <i>A. baviensis</i> = <i>A. petelotii</i>, etc.

Sub-region	Indicator	Major characteristics
		- The type of bamboo forest and mixed bamboo and timber forests which is a secondary forest originating from hilly, low and medium mountainous evergreen mixed closed and broad leaved humid forests at the elevation of 500-1500m which consist of <i>Arundinaria</i> and <i>Phyllostachys</i> with the height of no more than 1,5-2m.
TV 6: Hoa Binh - Ninh Binh hilly terrains	Climate	T _{year} : 22-24 °C; R _{year} : 1600-2200 mm
	Geomorphology	Low mountains and hills, mixed between limestone and other sedimentary rocks, at the elevation of 300 - 700m.
	Soil	Mainly including Xanthic ferralsols and Ferralic Acrisols on degenerated sedimentary rocks which are formed by the feralite process. There are medium to thin soil class, medium humus, high erosion.
	Forest vegetation	- There are lowland evergreen mixed closed and broad leaved humid forests < 700m, however, very few of them are primary forests but most of them are secondary and human-intervened forests (after-cultivation). The ecological dominant layer of this forest type is usually formed by such species as <i>Hopea odorata</i>, <i>Vatica fleuryana</i>, <i>Canarium album</i>, <i>Pelthophorum</i> sp. and other timber species with the forest cover of 60-70% and medium elevation of 25-30m. - The forest type of bamboo forests and mixed bamboo and timber forests is the result of stronger recession process and in the areas where drier climate in dry season. The dominant layer is formed by <i>Bambusa</i> spp., <i>Dendrocalamus sericeus</i>, <i>Indosasa amabilis</i>, <i>I. crassiflora</i>, <i>Ampelocalamus patellaris</i>, <i>Neohouzeana dulloo</i>, etc mixed with <i>G. subaequalis</i>, <i>Castanopsis indica</i>, <i>Cratoxylon</i> spp., <i>Engelhardtia</i> spp., <i>Ilex</i> spp. etc.. - Type of plantations in the sub-region has such main forest types as <i>Acacia</i> spp., <i>Eucalyptus</i> spp., <i>Dendrocalamus</i> spp., etc. - In addition, the sub-region has about 20 dominant species under such genres as <i>Phalaris</i>, <i>Themeda</i>, <i>Paspalum</i>, <i>Imperata</i>, <i>Arundinella</i>, <i>Eragrostis</i> (Poaceae), <i>Artemisia</i>, <i>Chromolaena</i>, <i>Cirsum</i> and <i>Ageratum</i> (Asteraceae); <i>Rubus</i>, <i>Fragaria</i> (Rosaceae), <i>Melastoma</i> and <i>Blastus</i> (Melastomataceae); <i>Carex</i> (Cyperaceae) etc. Some timber species under such genres as <i>Salix</i> (Salicaceae), <i>Wendlandia</i> (Rubiaceae), <i>Mallotus</i> and <i>Macaranga</i> of Euphorbiaceae; <i>Eurya</i> (Theaceae) might be also found.

Sub-region	Indicator	Major characteristics
II. Northeast	Climate	The climate is strongly affected by sea zone air and by tropical air and sea equators. This region has the coldest winter over the country. $T_{\min}$ can be lower than 0°C . There is a possibility of frosts, frosts and even snows in high mountainous areas in the North. The climate is strongly divided. T_{year} is around $15\text{--}23^{\circ}\text{C}$; BDT_{day} : $8\text{--}10^{\circ}\text{C}$, BDT_{year} : $11\text{--}14^{\circ}\text{C}$. Low valleys have a temperature of more than 40°C in early dry season. Except for a short dry and hot weather in early winter. The climate is generally wet, much rainy with many rain centers with the rainfall of 2000-3000mm/year, and particularly 3000-4500mm/year in Bac Quang alone. There are some little rainy areas with the rainfall of only 1200-1400mm/year in Cao Bang – Lang Son. It is quite characterised by drizzling rain in spring; it is less affected by storms except for Quang Ninh coastal areas, solar radiation is relatively high, dramatically decreasing in the winter-spring period. It is very cold in winter and very cool in summer on high mountainous belts.
	Geomorphology	Low and medium mountainous blocks developed on different rocks. Many mountain ranges have a bow shape, steep slope and strong fragmentation
	Soil	Mainly including Ferralic Acrisols, Gleyic Acrisols, Humic Acrisols, Xanthic Ferralsols, Rhodic Ferralsols formed mica Schist, Plinthite rocks, limestone, granite and liparite rocks and sandy rocks; high erosion, medium to thick soil class, quite good fertility and humus, medium productive potential.
	Forest vegetation	The typical forest types include lowland evergreen mixed closed and broad leaved humid forests less than 700m with representative species such as <i>Hopea</i> spp., <i>Vatica</i> spp., <i>Canarium alba</i> ; hilly, low and medium mountainous evergreen mixed closed and broad leaved humid forests 500-1500m with species such as <i>Castanopsis</i> spp., <i>Lithocarpus</i> spp., <i>Quercus</i> spp., <i>Eberhardtia tonkinensis</i> and especially coniferous forests, mixed broad-leaved and coniferous forests with (<i>Pinus kesiya</i>). Plantations in the region are mainly <i>Cunningamia lanceolata</i> , <i>Mangleitia</i> spp., <i>Acacia</i> spp., <i>Eucalyptus</i> spp., <i>Styrax tonkinensis</i> for pitwood and wood materials etc...
TV 7:	Climate	T_{year} : $22\text{--}24^{\circ}\text{C}$; R_{year} : 1600-2000 mm

Sub-region	Indicator	Major characteristics
Hong and Chay rive valleys	Geomorphology	The mountainous terrain is dominant in the North, including route-based topography to the Northwest – Southeast with the absolute elevation of over 2,000m; there is a hilly and bowl-shaped terrain in the Southeast. The central part is the valley terrain, including alluvial and relatively flat flood-plain benches.
	Soil	Mainly including Ferralic Acrisols found Mica Schist, sedimentary rocks and acid formed by the feralite process; thick layers, medium fertility and humus
	Forest vegetation	- Lowland evergreen mixed closed and broad leaved humid forests less than 700m are often found on weathered soil formed from parent rocks such as Schist, Sandstone, Granite and Daxite except for limestones. The primitive forest status is hardly founded while secondary statuses which are intervened by human at the different levels of impacts and which are on the process of regressive or evolutionary succession are found. Within the populations which have been rehabilitated into a sustainable process, ecological dominance layer includes species as <i>Hopea odorata</i>, <i>Vatica fleuryana</i>, <i>Canarium album</i>, <i>Pelthophorum</i> spp. and other timber species with the forest cover of 60 – 70% and medium height of 25 – 30m. At the successive phases prior to the sustainable period, species such as <i>Gironniera subaequalis</i> + <i>Garcinia oblongifolia</i> + <i>Mallotus</i> spp.; <i>Prunus arborea</i> + <i>Ormosia</i> spp. + <i>Parashorea chinensis</i>, <i>Michelia</i> spp. + <i>Aglaia gigantea</i> + <i>Pometia pinata</i>. - Low and medium mountainous evergreen mixed closed and broad leaved humid forests (at the elevation of > 500m); there are differences in species composition at the different elevation. At the elevation of at least 900m, such semi-tropical genera as <i>Eberhardtia</i> (Sapotaceae), <i>Acer</i> (Aceraceae), <i>Eriobotrya</i> (Rosaceae), <i>Michelia</i> (Magnoliaceae) etc... are found. At the elevation of > 1,000m, there are additionally coniferous forests, especially such species as <i>Fokienia hodginsii</i>. However, ecological dominance is characterized by Fagaceae species, i.e. <i>Castanopsis ceratocantha</i>, cC. <i>Chinensis</i>, <i>C. fleuryi</i>..., some species such as <i>Engelhardtia</i> spp., <i>Actinodaphne pilosa</i>, <i>Styrax tonkinensis</i>, <i>Betula alnoides</i>, and <i>Michelia</i> spp., <i>Paramichelia</i> spp....

Sub-region	Indicator	Major characteristics
		- Bamboo forest types and mixed bamboo and timber forests mainly include <i>Dendrocalamus membranaceus</i> , <i>D. sericeus</i> , <i>Bambusa vulgaris</i> , <i>Ampelocalamus patellaris</i> , <i>Arundinaria</i> spp., <i>Neozheana dulloa</i> , <i>I. amabilis</i> , <i>I. crassiflora</i> ... mixed with some peer timber species scattered such as <i>Castanopsis indica</i> , <i>Lithocarpus corneus</i> , <i>Gironniera subaequalis</i> , <i>Mallotus barbatus</i> , <i>Mallotus philipinensis</i> , <i>Macanga denticulata</i> , <i>Litsea cubeba</i> ...
TV8: Hoang Su Phi medium Mountain	Climate	T _{year} : 16-23 °C; R _{year} : 1400-1800 mm
	Geomorphology	Mountainous blocks were established on primitive base which is strongly horizontally and vertically dissected. They have steep slopes. The topography tends to be lower from the North to the South and from the Northeast to Southwest. The elevation of the sub-region is at least 1,600 – 1,700m to the North and at least 1,000m to the Southwest (including low and medium mountainous blocks). There are many mountain tops at the elevation of more than 2,000m.
	Soil	Mainly including Ferralic Acrisols and Humic Acrisols formed on acid extravasated rocks and degenerated rocks formed by the humic feralite and feralite processes. Quite good soil fertility and humus.
	Forest vegetation	The forest vegetation is characterized by coniferous forests in which dominant species are <i>Pinus keyisia</i> . This subregion also has low and medium mountainous evergreen mixed closed and broad leaved humid forests at the elevation of 500-1500m and high mountainous evergreen mixed closed and broad leaved humid forests at elevation of over 1500m.
TV 9: Song Lo, Song Gam river upstreams	Climate	T _{year} : 21-23 °C; R _{year} : 1800-4500 mm
	Geomorphology	The mountainous terrain is dominant in the entire sub-region, including route-based topography to the Northwest – Southeast, with the absolute elevation and many mountain tops over 2,000m; hilly terrain and bow-shape topography to the South alternatively inserted with quite flat small valleys
	Soil	Mainly including Ferralic Acrisols, Gleyic Acrisols and Rhodic Ferralsols on degenerated rocks formed by the feralite process; thick soil, quite good fertility and humus.

Sub-region	Indicator	Major characteristics
	Forest vegetation	Lowland evergreen closed and mixed broad-leaved < 700m and hilly, low and medium mountainous evergreen closed and mixed broad leaved forests at the elevation of 500-1500m with such dominant species under the family Fagaceae, family Euphorbiaceae, family Lauraceae, family Moraceae... In addition, there are such coniferous species as <i>Podocarpus neriifolius</i> , <i>Decussocarpus wallichianus</i> , <i>Fokienia hodginsii</i> .
TV 10: Low mountains Bao Lac, Ba Be	Climate	T _{year} : 15-22°C; R _{year} :1200-1600 mm
	Geomorphology	The terrain of mountainous blocks which are strongly horizontally and vertically dissected. They have steep slopes. The medium elevation is about 1,000 – 1,500m.
	Soil	Mainly including Humic alisols (Humic acrisols), Feralit alisols on sedimentary rocks; medium and thin soil class; low and medium soil fertility.
	Forest vegetation	The typical forest types are mixed forests on limestone mountains and on sloppy topography and thin soil which is often dry, therefore, plant composition is relatively poor. However, due to complicated topography, diversified arrangement of rocks on base surface plus climate division, plant elements distributed in different areas have remarkable distinguishments. In the upright steep areas, major plants are mainly small trees, liana, drought-resistant species such as <i>Bauhinia</i> spp., <i>Caesalpinia minax</i> ... In the gently sloppy areas there are such species as <i>Taxotrophis ilicifolius</i> , <i>Rhaphis micrantha</i> , <i>Alphonsea tonkinensis</i> , <i>Schefflera leucantha</i> , <i>Hydrocarpus annamensis</i> ... Large-sized species are scatteredly growing along caves and sea walls, including <i>Burretiodendron hsienmu</i> , <i>Garcinia fragracoides</i> , <i>Chukrasia tabularis</i> , <i>Dysoxylum hainanense</i> var. <i>glaberrimum</i> , <i>Adenanthera lucida</i> , <i>Pometia pinnata</i> , <i>Paviesia annamensis</i> The dominance includes <i>Diospyros sylvatica</i> ; <i>Quercus bambusaefolia</i> ; <i>Rhododendron</i> spp.; <i>Burretiodendron hsienmu</i> ; <i>Lithocarpus</i> spp.
TV 11: Dong Van Limestone Mountain	Climate	T _{year} : 15-22 °C; R _{year} : 1200-1600 mm
	Geomorphology	Upright steep limestone mountains interruptedly and alternatively located in low mountainous block terrain on different rocks. The elevation is lower from the North to the South (Bac Son)
	Soil	Mainly including Xanthic ferralsols, Rhodic ferralsols, and Ferralic acrisols on acid sedimentary rocks formed by the humic feralite process. thin/medium soil class, strong erosion, with many resurfaced rocks, quite good fertility and humus

Sub-region	Indicator	Major characteristics
	Forest vegetation	- Typical forest types are mixed limestone mountainous forests on steep topography; thin soil class which is usually lacking water, thus the flora here is quite poor. However, due to complicated topography, diversified rock location on base surface plus climate division, the flora distributed in various areas has remarkable distinguishments. In the upright steep areas major plants are small trees, liana and drought-resistant species such as <i>Bauhinia</i> sp., <i>Caesalpinia minax</i>, etc. In gently sloping areas such species as <i>Taxotrophis ilicifolius</i>, <i>Rhaphis micrantha</i>, <i>Alphonsea tonkinensis</i>, <i>Schefflera leucantha</i>, <i>Hydrocarpus annamensis</i>, etc., are distributed. - Large-sized species are scatteredly growing along caves and sea walls such as <i>Burretiodendron hsienmu</i>, <i>Garcinia fragracoides</i>, <i>Chukrasia tabularis</i>, <i>Dysoxylum hainanense</i> var. <i>glaberrimum</i>, <i>Adenanthera lucidor</i>, <i>Pometia pinnata</i>, <i>Paviesia annamensis</i> etc. - Major dominances include <i>Diospyros sylvatica</i>; <i>Rhododendron</i> spp.; <i>Quercus bambusaefolia</i>; <i>Castanopsis</i> spp.; <i>Brretiodendron hsienmu</i>
TV12: Midland Phu Tho, Vinh Phuc, Thai Nguyen, Bac Giang	Climate	T _{year} : 23-24 °C; R _{year} : 1400-1600 mm
	Geomorphology	The hilly terrain alternatively distributed at the relative elevation of 100-120m, having slopping arch shaped peaks or linked arches with relative large and plain valleys between hills. Unclear hilly directions, which could be reflected through the confusion of hydrometeorology network direction in the sub-region.
	Soil	Mainly Ferralic Acrisols on mica schist, acid sedimentary rocks and ancient alluvial formed by the feralite process. Thin/medium soil class, very strong erosion and laterite, many conglomerated Laterite, poor fertility and humus in deforested areas.

Sub-region	Indicator	Major characteristics
	Forest vegetation	- Lowland evergreen mixed and closed forests <700m: majority of them were strongly impacted, there are only secondary rehabilitated forests left, including such species as <i>Castanopsis</i> spp., <i>Syzygium</i> spp., <i>Ormosia balansae</i>, <i>Cinnamomum</i> spp., <i>Garcinia boni</i>, <i>Garcinia cowa</i>, <i>Knema</i> sp., <i>Elaeocarpus</i> spp., <i>Canarium album</i>, <i>Gironniera subaequalis</i>, <i>Engelhartia roxburghiana</i>,... The shrub layer at the height of 4 -5m is quite dense. Popular species include the species of such families as Rubiaceae, Myrsinaceae, Elaeocarpaceae, Sterculiaceae, Ancistrocladaceae, Rutaceae, Euphorbiaceae, Symplocaceae, Melastomataceae, <i>Arundina</i> sp., <i>Neohouzeana dullosa</i>,... Fresh vegetation mainly includes species of such families as Araceae, Acanthaceae, Zingiberaceae, Poaceae, Cyperaceae. Popular liana are the species of such families as Vitaceae, Fabaceae, Capparadaceae, etc - Bamboo forests and mixed bamboo and timber forests: their dominant species include <i>Neohouzeaua</i>, <i>Indosasa</i>, <i>Melocalamus</i> and alternatively distributed and inserted such timber species as <i>Macaranga denticulata</i>, <i>Styrax tonkinensis</i>, <i>Ormosia balansae</i>, <i>Engelhartia roxburghiana</i>, <i>Trema orientalis</i>, <i>Castanopsis</i> spp., <i>Gironniera subaequalis</i>, <i>Cinnamomum</i> spp., <i>Machilus</i> spp., <i>Garcinia boni</i>, <i>Garcinia cowa</i>, <i>Liquidambar formosana</i>, etc. - In addition, many drought-resistant grassy species are found in this sub-region, including <i>Saccharum spontaneum</i>, <i>Thysanolaena maxima</i> and <i>Imperata cylindrica</i> formed on degenerated post-harvesting soil or unsurvived plantations. The shrub species mainly include <i>Phyllanthus emblica</i>, <i>Aporosa sphaerosperma</i>, <i>Wendlandia paniculata</i>, <i>Cratoxylum polyanthum</i>, <i>Wrightia pubescens</i>, <i>Randia spinosa</i>, <i>Rhodomyrtus tomentosa</i>, <i>Melastoma tomentosa</i>,... Scattered timber species include <i>Liquidambar formosana</i>, <i>Alangium kuzii</i>, <i>Alangium chinense</i>, <i>Elaeocarpus</i> spp., <i>Sterculia</i> sp, <i>Rhus chinensis</i>, <i>Litsea cubeba</i>, <i>Litsea</i> sp., v.v. - Plantations in this sub-region are mainly <i>Eucalytus</i> spp., <i>Acacia</i> spp., <i>Pinus masoninus</i> and some other indigenous species.
TV 13: Bac Son Limestone Mountain Block	Climate	T _{year} : 20-22 °C; R _{year} : 1400-1600 mm
	Geomorphology	Low karst mountains with very steep slope, interruptedly and alternatively located between denuded and eroded low mountains on different types of rocks. The evaluation is changing from the North to the South (Bac Son)

Sub-region	Indicator	Major characteristics
	Soil	Mainly including Rhodic ferralsols, Xanthic ferralsols, Ferralic Acrisols on limestone alternatively mixed with acgilit rocks and shale formed by the feralite process; strong erosion, with many resurfaced rocks, thin to medium layers
	Forest vegetation	Vegetation layer mainly includes limestone mixed forests. However, forest eco-systems in the sub-region were strongly affected. On the limestone mountain sides, vegetation is mainly formed by such species as <i>Brretiodendron hsienmu</i> , <i>Garcinia fragracoides</i> , <i>Paviesia annamensis</i> , <i>Syzygium</i> spp., etc..., representing by 25-30% of standing tree composition. Drought-resistant species occupy a large percentage. The lower storey which is remarkably established includes trees with bent stems and early branching off such as <i>Xanthophyllum</i> sp., <i>Taxotrophis ilicifolius</i> , etc... accounting for 30-40% of the composition. On limestone mountain peaks, vegetation layers are quite thin and mainly formed by such species as <i>Taxotrophis ilicifolius</i> , <i>Paviesia annamensis</i> , <i>Nephelium</i> spp., <i>Euphoria</i> sp.
TV 14: Low mountains Cao bang, Lang Son and Quang Ninh	Climate	T _{year} : 18-23 °C; R _{year} : 1100-1800 mm
	Geomorphology	Massive mountain block which is strongly horizontally and vertically dissected, with steep slopes. The medium elevation is about 1,000 – 1,500m. The Mountain Range has a arch shape with different directions, mainly to the Northwest – Southeast
	Soil	Mainly including Ferralic Acrisols and Rhodic ferralsols on acgilit rocks, shale, denatured schist, limestone, granite and liparite rocks, sandstons etc..formed by the feralite process. There are thin/medium soil class, strong erosion, low fertility and humus
	Forest vegetation	- Lowland evergreen mixed closed and broad leaved humid forests less than 700m with many valuable tree species such as <i>Erythrophloeum fordii</i>, <i>Vatica tonkinensis</i>, <i>Madhuca pasquieri</i>, <i>Sindora tonkinensis</i>, etc. - Bamboo forests and mixed timber and bamboo forests widely developed in the sub-region as a consequence of the regression of evergreen mixed closed and broad leaved humid forests. - Plantations include such major species as <i>Acacia</i>, <i>Pinus massoniana</i>, <i>Cunningamia</i> sp., <i>Mangleitia glauca</i>, <i>Styrax tonkinensis</i>, etc.

Sub-region	Indicator	Major characteristics
		- In addition, this subregion has shrubs, including such light-demander species, drought-resistant species, hard-leaved forests and thorn trees. High vegetation mainly includes such species as <i>Saccharum spontaneum</i> , <i>Miscanthus japonicus</i> , Chít <i>Thysanolenia maxima</i> , etc. Low vegetation layer is mainly <i>Imperata cylindrica</i> .
TV 15: Coastal Mangrove along Northeast coastline	Climate	T _{year} : 22-23 °C; R _{year} : 2000-2800 mm
	Geomorphology	Less than 10m, flat and soft tidal area
	Soil	Mainly including wetland on the sedimentary base formed by the tide, thin layer, with many resurfaced rocks, poor clay, acidity
	Forest vegetation	- Coastal forest types: Mangrove population in the Northeast is characterized by a relatively abundant mangrove flora, including high salinity-resistant species, without typical brackish water-demander species typical of brackish water, except for inland quagmire such as in Yen Lap and a part of southern Bach Dang river due to being influenced by a large river system. The mangrove populations are mainly: + <i>Avicennia marina</i> purely growing on new alluvial. + Mixed population including <i>Rhizophora stylosa</i> , <i>Kandelia candel</i> , <i>Bruguiera gymnorrhiza</i> on medium tidal flats. + <i>R. gymnorrhiza</i> population on high tidal flats, + Mixed populations, i.e. <i>Excoecaria agallocha</i> , <i>Lumnitzera racemosa</i> , <i>Scyphyphora</i> sp., <i>Myoporum bontiodides</i> on very high tidal flats. There are salt-resistant species populations which are not directly impacted the tide, mainly including <i>Xylocarpus obovatus</i> , <i>Heritiera littoralis</i> , <i>Hibiscus tiliaceus</i> , <i>Cerbera manghas</i> , <i>Thespesia populnea</i> , <i>Scaevola tâccda</i> , <i>Clerodendron inerme</i> on the rarely-inundated tidal flats ...
TV 16: Northeast islands (Cat Ba, Bach Long Vi)	Climate	T _{year} : 23-24 °C; R _{year} : 1100-1600mm
	Geomorphology	Low mountains, hills and dunes are alternatively located. Different elevations has different elevations
	Soil	Mainly new Fluvisols which is not annually consolidated by the Red River and Thai Binh rivers; less acid or neutral soil; quite high fertility mixed with Distric fluvisols, Gleyic fluvisols, ancient fluvisols, Ferralic acrisols, strong erosion and poor fertility.

Sub-region	Indicator	Major characteristics
	Forest vegetation	The coastal mangrove forests usually create mixed populations mainly including such species as <i>Rhizophora stylosa</i>, <i>Bruguiera gymnorhiza</i>, <i>Kandelia ovata</i> etc. Forest layer is usually 2-3 m in height. There are small timber species and shrubs such as <i>Aegiceras corniculatum</i>, <i>Avicennia marina</i> under forest canopy, creating a high vegetation of more or less 1 meter. Mixed closed humid vergreen broadleaf forest on elevation (lower than 700 m abs in the North or lower 1000 m abs in the south) is found on mountain sides and cliffs. Popular timber species are <i>Livistona halongensis</i>, <i>Dalbergia candenatensis</i>, <i>Ficus alongensis</i>, <i>Pterospermum truncatolobatum</i>, <i>Sterculia lanceolata</i>... Shrubs are usually <i>Cycas trophophylla</i>, <i>Dracaena cambodiana</i>, <i>Pandanus odoratissima</i>... growing into clusters of pure species. The mixed limestone forests are mainly distributed in Cat Ba island which is characterized by evergreen closed forests consisting of a quite variety of different species. There are at least nearly 900 vascular plants found in this forest type.
III. Red river Delta	Climate	The climate is strongly affected by sea zone air and tropical sea air; hot and high humid weather; with quite cold weather in winter; quite homogenous terrain, less strong climate division. T_{year} is about 23-24°C. T_{min} is less likely to be below 0°C in the North and below 5°C in the South; with hot summer; T_{max} can reach 40°C in early summer in some areas, the South alone might be influenced by hot and dry weather. It is also directly impacted by sea, therefore the daylight temperature is quite low (<8°C); with high rainfall and quite high rainfall intensity, R_{year} is about 1600-1800mm/year with 2 remarkable different seasons, i.e. rainy season and dry season. There is a quite typical humid season characterized by drizzle and extremely high humid in spring – winter season; solar radiation is quite high, however, dramatically decreasing in winter – spring season; it is directly and strongly affected by storms, especially in coastal areas.
	Geomorphology	Hilly terrain and deltas
	Soil	Mainly new Fluvisols which is not annually consolidated by the Red River and Thai Binh rivers; less acid or neutral soil; quite high fertility;

Sub-region	Indicator	Major characteristics
	Forest vegetation	Mainly including evergreen mixed closed and broad leaved humid forests in the Midland subregion Pho Tho and Bac Giang; bamboo forests and mixed timber and bamboo forests; different types of plantations in the Delta and coastal mangrove forests in the red river delta wetland sub-region. This sub-region's forestry development focus is to develop and consolidate protection forest system, industrial environment, urban areas and coastal areas
TV 17: Red river delta	Climate	T _{year} : 23-24 °C; R _{year} : 1500-1800 mm
	Geomorphology	Red river and Thai Binh river Deltas at the elevation of lower than 10m.
	Soil	Mainly new Fluvisols which is not annually consolidated by the Red River and Thai Binh river; less acid or neutral soil; quite high fertility mixed with Distric fluvisols, Gleyic fluvisols, ancient fluvisols, Ferralic acrisols, strong erosion and poor fertility.
	Forest vegetation	- Different types of plantations including scattered trees and home garden trees. - There are also shrubs and savanna
TV 18: Mangrove forests of the Red river delta	Climate	T _{year} : 23-24 °C; R _{year} : 1600-1800 mm
	Geomorphology	Coastal tidal flats, soft materials, creating not very large strips of land
	Soil	Mainly medium saline soil and Gleyic fluvisols on coastal alluvial land and riverine areas of Redriver and Thai Binh river; daily-inundated, with many clays and quite high fertility;
	Forest vegetation	Mangrove coastal forests: with lower diversity in the Northeast region due to inconvenient natural conditions unfavorable to resettlement and development of mangrove species. The mangrove forest populations are characterized by such brackish water-demanding species as <i>Sonneratia caseolaris</i> . Under the canopy of <i>Sonneratia caseolaris</i> , there are species such as <i>Avicennium. Corniculatum</i> and <i>Acanthuss ilicifolius</i> , creating shrubs mixed with <i>Kandelia candel</i> or <i>Cyperus malaccensis</i> growing into small clusters.

Sub-region	Indicator	Major characteristics
IV. Northern Central Region	Climate	The winter is affected by sea zone air. The air intensity fastest decreases to the back of the Ngang Pass. The Foehn effects have strongly denatured tropical airs from the West. The basic feature of the climate is dry and humid, however, it is sometimes very typical dry and hot. The climate is quite strongly divided. T_{year} : 18-25°C. The winter is quite cold, and fast decreasing to the back of Ngang Pass, to Hue drizzle occurs, however, the temperature is 20 °C there. The prevailing dry and hot weather in lowland, especially in front of Passes where attracts the winds from the southwest, increasing the temperature, i.e. $T_{\text{max}} > 40^{\circ}\text{C}$, even up to 42-43°C. Since it is located on the eastern side of the Truong Son Mountain Range, it is strongly affected by sea, BDT_{day} : 7-9 °C. With heavy rain but not equally. R_{year} fluctuates 1100-4000mm/year with the 2 big rain centers with R_{year} : 2000-4000mm and an area with low rainfall R_{year} 1100-1400mm. The rain season is shifting into spring, which is absolutely different from other areas in the North Central Region; quite high solar radiation, unequal distribution; the climate is strongly affected by storms
	Geomorphology	The terrain is clearly sub-staged from the West to the East. To the West, low mountain blocks are developed on different types of rock, then hilly areas are found, and then strips of plains and coastal dunes are seen; the mountainous terrain is strongly divided and has high steep
	Soil	Mainly including Ferralic Acrisols, Gleyic Acrisols, Humic Acrisols, Rhodic Ferralsols, Xanthic Ferralsols, Lithic Leptosols, Distric Fluvisols and coastal dunes; strong erosion, strong laterite process, low acidity, poor fertility and low productive potential.
	Forest vegetation	Typical forest types include: - Lowland evergreen mixed closed and broad leaved humid forests < 700m and hilly, low and medium mountainous evergreen mixed closed and broad leaved humid forests 500-1500m with high biodiversity such as National Parks of Pu Mat, Vu Quang and Phong Nha Ke Bang. - Semi-deciduous mixed forests with representative species of such families as Lytracaceae, Combretaceae, Magnoliaceae, Sapindaceae in dry sub-region named Muong Xen. The forestry development focuses on consolidating watershed protection forest system, sand-break forests and developing material-oriented zones for timber and NTFP supplies.
TV 19:	Climate	T_{year} : 18-23 °C; R_{year} : 1100-1400mm

Sub-region	Indicator	Major characteristics
Muong Xen	Geomorphology	Massive mountainous blocks, strongly dissected, high steeps; medium elevation of 1000-1500m.
	Soil	Mainly including semi-dry Haplic lxisols, Ferralic acrisols, Humic acrisols on acgilit rocks, shales and denatured schist formed by the feralite and humic feralite processes. Quite good soil fertility and humus.
	Forest vegetation	Semi-deciduous mixed forests are characterized by the flora migrating from the dry and hot West, establishing dry seasonal deciduous tropical forests with primitive or secondary vegetation covers which includes thin density of trees and deciduousness in dry season. The flora is mainly formed by species of such families as Lythraceae, Combretaceae, Magnoliaceae, Sapindaceae, Symplocaceae, Rubiaceae, Myrtaceae, Datisceae, Euphorbiaceae, Hypericaceae... and different kinds of bamboo. Dominant trees are species of such genres as <i>Lagestroemia</i> (Lythraceae), <i>Cratoxylon</i> (Hypericaceae), <i>Wendlandia</i> (Rubiaceae), <i>Aporosa</i> (Euphorbiaceae). These species are highly adaptative to living and hot living conditions.
TV 20: Mountainous area to the West of Thanh Hoa, Nghe An and Ha Tinh	Climate	T _{year} : 19-24 °C; R _{year} : 1400-3000 mm
	Geomorphology	Massive mountainous blocks, strongly dissected, high steeps; medium elevation of 1000-1500m.
	Soil	Mainly including Ferralic acrisols, Gleyic acrisols, Humic acrisols, Rhodic ferralsols, carbonate soil on acgilite rocks, schist, limestone and granite rocks formed by feralite and humus feralite processes; with quite good soil fertility and humus.
	Forest vegetation	Popular forest types are hilly, low and medium mountainous evergreen mixed closed and broad leaved humid forests (lowland less than 700m and hilly, low and medium mountains at the elevation of 500-1500m) with very high biodiversity. This sub-region has recognized at least 2,500 vascular plants, including 23 species listed in the Vietnamese Redbook 2007. The area with the richest flora diversity is Pu Ma National Park where inventoried 2,461 vascular plants, including some new species. This forest type is dominated by species of such families as Dipterocarpaceae: <i>Hopea</i> spp. and <i>Dipterocarpus</i> spp., Fagaceae: <i>Quercus</i> spp., <i>Lithocarpus</i> spp. and <i>Castanopsis</i> spp., Lauraceae: <i>Cinnamomum</i> spp. and <i>Litsea</i> spp.

Sub-region	Indicator	Major characteristics
		- At the higher elevation, evergreen low mountainous forests are founded. At the lower elevation of 1,500m, this forest type is dominated by species of such families as Fagaceae, Lauraceae and Myrtaceae, however, some Dipterocarpaceae species are still seen in this forest type. - At the elevation less than 1,500m, Dipterocarpaceae species are not absolutely found. The vegetation cover is characterized by such species as <i>Cunninghamia konishii</i>, <i>Fokienia hodginsii</i> and <i>Decussocarpus wallichianus</i>. The forest areas which have not yet been impacted is distributed along high mountains to the southwest of the sub-region. The average volume is 150-250 m³/ha. In addition, bamboo forests and mixed timber and bamboo forests are also founded as a consequence of forest degradation
TV 21: North Central hilly terrain (6 provinces)	Climate	T _{year} : 22-24 °C; R _{year} : 1600-4000 mm
	Geomorphology	The hilly terrain alternatively distributed at the relative elevation of 100-120m, having slopping arch shaped peaks or linked arches with relative large and plain valleys between hills. Unclear hilly directions, hills are often dissected by low mountain ranges.
	Soil	Mainly including Ferralic Acrisols, Lithic leptosols, Calcic Luvisols on sedimentary rocks, limestone, granite, liparite, poocphia and basalt formed by the feralite process; strong erosion and laterite process, thin and medium soil class, acidic soil, with many conglomerated Laterite, poor fertility
	Forest vegetation	- Lowland evergreen mixed closed and broad leaved humid forests less than 700m, however, not many primitive forests exist, mainly only secondary forests which recover after the strong human interventions as well as newly-regenerated and protected forests. There are some good quality natural forests such as <i>Erythrophleum fordii</i> and <i>Santolis</i> forests in Tam Quy, Ha Tan, Ha Trung, Thanh Hoa, <i>Caesal-Tarrietia javanica</i> forests at the foot of Ba Ren Mountain, Ru Linh area in Vinh Linh, Quang Tri. - Vegetation are shrubs occupying a large area in the North Central hilly terrain. - The plantation ecosystems are formed by such timber species as <i>Pinus</i>, <i>Eucalyptus</i>, <i>Acacia</i>. Perennial species are <i>Cofea</i> sp., <i>Piper nigrum</i>, <i>Thea sinensis</i>, fruit trees and crops like <i>Manihot</i>, <i>Zea mays</i>, <i>Phaseolus</i> etc. They are gradually replacing natural ecosystem on hilly terrains.
TV 22:	Climate	T _{year} : 23-25 °C; R _{year} : 1600-3000 mm

Sub-region	Indicator	Major characteristics
Delta and coastal sandy dunes of the North Central Region	Geomorphology	The coastal plain terrain mainly has an elevation of lower than 10m although some areas has elevation less than 20m. Major terrains include coastal sandy plain, inland sandy plains, accumulated river delta, marine – riverine plains and plain benches with different origins.
	Soil	Mainly including arenosols, Distric fluvisols mixed with Lithic leptosols on acid sedimentary rocks, strong erosion caused by winds and water flows, poor fertility
	Forest vegetation	- Lowland evergreen mixed closed and broad leaved humid forests less than 700m: which are mainly formed by low timber species with medium parameters and low branching-off and hard-leaved. Species composition mainly include species of such families as Myrtaceae, Lauraceae, Clusiaceae, Euphorbiaceae and some plants of such families as Dipterocarpaceae, Fagaceae, Flacourtiaceae... Popular dominances are often found on dunes, including: <i>Xylosma controversum</i> + <i>Syzygium chalos</i>; <i>Castanopsis ceratacantha</i>; <i>Lithocarpus concentricus</i>; <i>Cratoxylon prunifolium</i>; <i>Vatica obtusifolia</i>; <i>C. ceratacantha</i>, <i>L. sabulicolus</i>, <i>L. dinhensis</i>; <i>Melaleuca cajeputi</i>. - Major plantations are casuarina and drought-resistant Acacia species
TV 23: Phong Nha – Kẻ Bàng limestone mountain	Climate	T _{year} : 22-25 °C; R _{year} : 2000-2200 mm
	Geomorphology	Limestone terrain, steep slopes that locate alternatively with small and relatively flat valley. Popular altitude is less than 1000m.
	Soil	Feralit mostly gray soil, red brown, golden brown on the limestone, acgilit, shale, chalk sa, metamorphic slab. Thin – medium layer, with numerous resurfaced rocks, less acidic and rather high fertility and mud.
	Forest vegetation	Mixed species forests on limestone mountain are typical forest type: Forest ecosystem on limestone are widely distributed throughout the region and contain rich and diversified biological resources in the region. Dominant species are broad leaved ones of different families as Fagaceae, Lauraceae, Euphorbiaceae, Magnoliaceae, Fabaceae, Sapotaceae. Dominant species with large quantity that form flora population are <i>Castanopsis indica</i> , <i>Lithocarpus dussaudi</i> , <i>Lithocarpus coachilus</i> , <i>Quercus fleury</i> of Fagaceae family. In this area, there are also number of species belonging to Lauraceae of <i>Cinnamomum</i> genus; many valuable timber species of Magnoliaceae family could be seen in this area such as <i>Tsoogiodendron odorum</i> , <i>Manglietia dandy</i> .

Sub-region	Indicator	Major characteristics
		At the elevation from 1,000m up, there exist other species as <i>Quercus bambusaefolia</i> ; <i>Archidendron tonkinense</i> , in addition to various species of <i>Cinnamomum</i> genus, Lauraceae family. It is noticeable that at this elevation, numerous Gymnospermae species are recorded as <i>Dacrycarpus imbricatus</i> , <i>Dacrydium elatum</i> , <i>Podocarpus neriifolius</i> ; <i>Calocedrus rupestris</i> could be found in this area as well. Gymnospermae species are often distributed on upper storey where large timber could be recognized from afar so as to create a mixed broad and needle leaved forest. On Phong Nha, Ke Bang limestone, there are at least 1,214 vascular plants of 581 genus and 158 families.
TV 24: Mountain in western part of Bình Trị Thiên	Climate	T _{year} : 20-22 °C; R _{year} : 2000-3500 mm
	Geomorphology	Massive mountain block foundation oriented terrain type with deep and horizontal cleavage and sloppy hill. The sub-region's elevation is taken from the belt from 1000m up.
	Soil	Mainly gray feralit soil, gray Glay, gray humus, soil erosion inert acgilit gravel on rock, shale, chalk sa, metamorphic slabs, granite is formed through feralit and mud feralit process. Average thick storey with rather high fertility and mud.
	Forest vegetation	- Lowland evergreen broad leaved, closed, mixed and rainy forest at elevation of below 700m and low hilly and mountain area of average elevation from 500-1500m: having typical characteristics of northern Vienam – Southern China's indigenous flora, which is reflected through the distribution of various families as Lauraceae; Moraceae; Fagaceae; Fabaceae; Ebenaceae; Magnoliaceae; Sterculiaceae; Meliaceae; Sapindaceae; Sapotaceae; Clusiaceae; Cupressaceae.... At the same time, this area is seen as a convergence of the 3 big plant migration streams, incorporating additional factors of these flora.

Sub-region	Indicator	Major characteristics
		+ Evergreen broad leaves, closed, mixed, rainy forest on low and medium mountain distribute from the elevation from 700 – 1,500m and allocate on mountain range along Truong Son road. This forest type is less intervened and still remains its primary characteristics. Ecosystem of such a forest type could be seen in areas that share border with Phong Nha – Ke Bang national park, Bac Huong Hoa nature reserve (Quang Tri province); Đakrông nature reserve (Quảng Trị province), some small area in PeKe mountain pass - A Lưới district, Thừa Thiên Huế, A Roàng area that closes to Thừa Thiên Huế and Quảng Nam province. + Evergreen broad leaved, closed, mixed and rainy forest in lowland at elevation below 700m is seen in Dacrong, Bac Huong Hoa nature reserve areas or some other areas in the sub-region. - Bamboo, rattan and mixed bamboo, rattan and timber species forest that formed after cultivation and over-exploited is originated from evergreen broad leaved, closed, mixed and rainy forest at the elevation below 700m. - Various types of plantation forest: there exist intensive large forest areas of the following species <i>Acacia mangium</i>, <i>Acacia</i> spp., <i>Eucalyptus camdulensis</i>, <i>E. europphyllus</i> and different <i>Pinus</i> spp. as well as <i>Hevea brasiliensis</i>, <i>Coffea</i> spp.
V. Vùng Nam Trung Bộ	Climate	This region is mainly influenced by tropical and ocean equatorial air flow rather than by the denatured tropical extreme air. Typical tropical climate without winter. Climate division is rather high in the region. T_{year}: 20-26°C. Foehn effect of blowing air from western part has created dry and hot period in lowland, $T_{max} > 38^{\circ}C$. Strong impact from sea, BDT_{day}: 7-9°C, BDT_{year}: 6-8°C. Heavy rain, R_{year}: 700-4000. Rainy center in northern part linkage with central highland to form a heavy rain area with R_{year}: 2000-4000mm. In the south-pole of south-central region, from Khanh Hoa to Binh Thuan is dry area with the lowest precipitation in the whole country, R_{year}: 700-1400mm. Rainy season entirely shifts toward Autumn-Winter season. Radiation is high, particularly in Ninh Thuan – Binh Thuan. Storm has high impact on coastal area from Khanh Hoa to Da Nang.

Sub-region	Indicator	Major characteristics
	Geomorphology	Topography is clearly distinguished from west to east. In the West, there is low block mountain that develop on various rocks, moving down to the hill and finally plain and coastal sandy beach. The coastal plain strip is strongly dissected by mountains crashing into the sea. High cleavage of mountain and terrain with high sloppy level.
	Soil	Mainly Ferralic acrisols, Distric fluvisols and sea sand that mix with a small quantity of Humic acrisols and Gleyic acrisols. Soil erosion and high laterit. Fertility and layer reduce while sand and conglomerate increase from high to low belt.
	Forest vegetation	- Evergreen broad leaved, closed, mixed and rainy forest on low and medium mountain at the elevation from 700-2000m: mainly distributed in the western part of Quang Nam and Quang Ngai province. - Thin, dry and seasonal deciduous forest of <i>Dipterocapus</i> dominance that could be found in hilly area of south coastal region which is close to the extremely dry region. - In addition, there are also drought resistant savanna and bushes. Forest development focus includes watershed protection to prevent sand blow and anti-desertification in extremely dry region.
TV 25: Mountain region in the west of Quang Nam – Quang Ngai	Climate	T _{year} : 19-22 °C; R _{year} : 2800-4000 mm
	Geomorphology	Massive mountain block foundation oriented terrain type with deep and horizontal cleavage and sloppy hill. The sub-region's elevation is taken from the belt from 1000m up.
	Soil	Mainly Ferralic acrisols, Humic acrisols, gnai, acgilit, Plinthosol and granit formed via feralit process. Medium layer with rather high fertility and mud.
	Forest vegetation	Evergreen broad leaved, closed, mixed and rainy forest on low and medium mountain of 700-2000m with various status, including primary status (intact). Results from different research and studies have indicated that on the territory of mountain sub-region on the west of Quang Nam – Quang Ngai, there are at least 731 vascular plants belonging to different genus of 130 families from 5 vascular plants as: Lycopodiophyta, Equisetophyta, Polypodiophyta, Pinophyta and Magnoliophyta.
TV 26:	Climate	T _{year} : 23-26 °C; R _{year} : 1600-3000 mm

Sub-region	Indicator	Major characteristics
South central hilly area	Geomorphology	Hilly terrain interspersed with relatively elevation from 100-120m, with domed top or wide and flat linkage between domes and valleys. Hilly direction is not clear. Hills are usually separated by low mountains that run across the sea
	Soil	Mainly Distric fluvisols in alternatively with Ferralic acrisols, Gleyic acrisols, Lithic leptosols, plinthosols shale, granite, gabro that are formed via feralit process. Medium and thin soil layer, strong soil erosion and laterit with low fertility and high conglomerate
	Forest vegetation	- Thin, dry and seasonal deciduous forest with <i>Dipterocapus</i> dominance: mainly distribute at the elevation below 300m on old thin and unfertile Fluvisols. Forest composition is rather simple, including only 2-3 storeys: one dominant timber storey at 15m height with low cover; one bush and one fresh vegetation storey. Composition of dominant species of Dipterocarpaceae family with the following species representatives: <i>Shorea obtusa</i>, <i>Shorea siamensis</i>, <i>Dipterocarpus intricatus</i>, <i>D. tuberculatus</i>, <i>D. obtusifolius</i>, and other species as: <i>Pterocarpus macrocarpus</i>, <i>Terminalia alata</i> = <i>T.tomentosa</i>, <i>Dalbergia nigrescens</i>, <i>Buchanaria reticulata</i>, <i>Irvingia oliveri</i>, <i>Castanopsis indica</i>, <i>Colona nubla</i>, <i>Actinodaphne pilosa</i>, <i>Peltophorum tonkinense</i>, <i>Vitex penduncularis</i> ... - Bamboo and mixed timber and bamboo forest: mainly formed after clear cut, burned or unused after cultivation. There are some key species as <i>Oxytenanthera dinhensis</i>, <i>O. hosseusii</i>, <i>O. poilanei</i>. In addition, there are also other bamboo species as <i>Bambusa agrestis</i> = <i>B. arundinacea</i>, <i>B. blumeana</i>, <i>B. lineate</i>, <i>Dendrocalamus poilanei</i>, <i>D. sericeus</i> = <i>D. sinuate</i>, <i>Gigantochloa cochinchinensis</i>, <i>G. multicaulis</i>, <i>Melocalamus compactiflorus</i>, <i>Schizostachyum zollingeri</i>... that grow alternatively with timber species as <i>Lagestroemia calyculata</i> = <i>L. angustifolia</i>, <i>L. petiolaris</i>, <i>Xylia</i> = <i>xylocarpa</i> = <i>X. dolabriformis</i>, <i>Pterocarpus macrocarpus</i>, <i>Vitex pinnata</i>, <i>Ormosia</i> spp.. - Plantation forest of different types: mainly plantation forest funded by donors with <i>Acacia</i> spp., <i>Eucalyptus</i> spp., <i>Pinus</i> spp. and some indigenous species as <i>Hopea odorata</i>, <i>Mimosops elengi</i>, <i>Erytrophoelum fordii</i>, <i>Peltophorum dasyrrhachis</i>,.
TV 27:	Climate	T _{year} : 26-27 °C; R _{year} 1300-2800 mm

Sub-region	Indicator	Major characteristics
Plain and coastal sandy beach in South-central region	Geomorphology	Coastal plain topographic type with elevation below 10m, sometimes can be below 20m, including the following types: coastal sandy plain, inland sandy plains, river accumulated delta, river-marine delta and deltas formed by various origins.
	Soil	Mainly marine sandy, Ferralic acrisols, Distric fluvisols that is alternatively with other soil types in a fragmented area. Strong soil erosion, thin layer, large sand quantity and unfertile.
	Forest vegetation	- Typical vegetation in this area is secondary vegetation on coastal sandy beach with dominant species of various genus as <i>Fimbristylis</i> (<i>F. paucifolia</i>, <i>F. sericea</i>, <i>F. subsspica</i>...), <i>Eragrostis</i>, <i>Chrysogogon</i>, <i>Germainia</i>, <i>Cyperus</i>, <i>Tribulus</i> (<i>T. terrestris</i>), <i>Spinifex littoratus</i>, <i>Ipomea pes-caprae</i>... Evergreen savanna on coastal sandy beach with elevation of 20.3m of various genus and species as: <i>Markhamia</i>, <i>Limnocyclus littoralis</i>, <i>Pleiospermium</i>, <i>Euphorbia</i>, <i>Opuntia dillenii</i>, <i>Albizia</i>, <i>Gluta megalocarpa</i>, <i>Castanopsis ceratocantha</i>, <i>C. armata</i>, <i>Barringtonia asiatica</i>, <i>Cerbera manghas</i>, <i>Syzygium bracteatum</i>. - Main plantation forest species are <i>Casuarina equisetifolia</i>, <i>Acacia</i> spp. and <i>Eucalyptus</i> spp..
TV 28: Hoàng Sa, Trường Sa	Climate	T _{year} : 26-27 °C; R _{year} : 1200-2400 mm
	Geomorphology	Floating island and submerged area under the 2 Hoang Sa and Truong Sa archipelages
	Soil	Mainly brown sand on Hoang Sa archipelago and various submerged coral while coastal sandy beach, submerged sandy beach and coral islands are dominant in Truong Sa archipelago.
	Forest vegetation	Typical vegetation is grass vegetation to be formed mainly from some species of Poaceae family as <i>Aristida chinensis</i>, <i>Chloris dolichostachya</i>, <i>Digitaria heterantha</i>, <i>Eragrostis alopecuroides</i>, <i>Heteropogon contortus</i>... There are total at least 64 species, of which Poaceae family is dominant.

Sub-region	Indicator	Major characteristics
		Flora community distribute at sandy strip along island. Sandy coastal strips is adjacent to the sea and is often flooded at high tidal. Main species are of Cyperaceae family as <i>Cyperus arenarius</i>, <i>C. stoloriferus</i>, <i>Fimbristylis argentea</i>, <i>F. sericea</i>, <i>Scirpus annamicus</i>, <i>S. littoralis</i>. Flora species grow scatteredly as <i>Serbera odollam</i>, <i>Argusia argentea</i> or grow intensively into individual groups as those of Cyperaceae family. Island coastal wetland community is dominated by some individuals of <i>Acanthus eberacteatus</i>, Acanthaceae family, <i>Scaevola taccada</i> – Goodeniaceae family, <i>Annona glabra</i> of Annonaceae family, or <i>Thespesia populnea</i> of Malvaceae family. These species grow scatteredly without forming flora community.
TV 29: South-central extreme hot region	Climate	T _{year} : 26-27 °C; R _{year} : 700-1400 mm; (Phan Rang: R _{year} (1958...1993): 693mm)
	Geomorphology	Mainly coastal sandy strips that form sandy dunes up to 50m.
	Soil	Mainly Chromic lxisols, red sand, white sand and sandy dunes, Ferralic acrisols, Ferralic acrisols that are alternatively distributed with many other soil types. Strong soil erosion, thin layer with large sand quantity, unfertile and dry. There exist neutral reaction with less acid.
	Forest vegetation	Popular vegetation is savanna, dry bushes with typical characteristics as drought resistant species as those belong to Annonaceae family such as <i>Dasymaschalon glaucum</i> , <i>D. macrocalyx</i> , <i>D. rostratum</i> , <i>Cyathocalyx annamensis</i> , <i>Mitrephora thorellii</i> ; Flacourtiaceae family with <i>Scolopia cinnamomifolia</i> , <i>S. sinensis</i> ; Capparaceae family with <i>Capparis flavicans</i> , <i>C. florobunda</i> , <i>C. trinerva</i> , <i>C. radula</i> ; Euphorbiaceae family with <i>Phyllanthus distichus</i> , <i>P. emblica</i> , <i>P. fasciculatus</i> , <i>P. reticulatus</i> ; Rutaceae family with <i>Atalantia bilocularis</i> , <i>A. citriodes</i> , <i>A. rotundifolia</i> , <i>A. roxburghiana</i> , <i>Citrus annamensis</i> ; Moraceae family with <i>Pseudostreblus indica</i> , <i>Taxotrophis ilicifolius</i> , <i>T. eberhardtia</i> .

Sub-region	Indicator	Major characteristics
VI. Central highland	Climate	Central highland has typical characteristic of a tropical mountainous climate, which is mainly influenced by tropical air and marine equatorial. There exists denatured tropical air, though having certain impact on northern mountainous area, the cold level is mainly decided by the topographical conditions. Being located in the west of Truong Son range, the climate is partly continental oriented with BDT_{day} 8- 11°C, BDT_{year} : 6-8°C. Climate is strongly divided, T_{year} : 16-26°C. In high mountainous areas, lowest temperature month is < 18°C, 6-7°C higher than those at similar elevation in the north-east region. Temperature in high mountain belt: T_{min} : 0 - 5°C. Temperature in low area, particularly during hot summer, T_{max} > 38°C. High precipitation, R_{year} : 1300-4000mm. In 2 high precipitation centers are in the north and south central highland: R_{year} : 2000-4000mm. Relative dry area is located in the middle with R_{year} : 1200-1400mm. Rainy and dry seasons are clearly distinguished. It is hottest and driest in Spring. High radiation and low influence from wind and storm.
	Geomorphology	Medium and low massive mountain that locate alternatively with basalt plateau and lowland, semi-plateau.
	Soil	Mainly Rhodic ferralsols, Chromic lxisols, Humic acrisols, Ferralic acrisols on granite, clay shale, bazan and old alluvium ground. There exists the largest Rhodic ferralsols area in Vietnam with relatively high fertility, mud and thick layer and tendency of moving from slow to high elevation belt.
	Forest vegetation	There remains the largest natural forest and rich forest area in the country. Main forest types are: evergreen, closed, mixed, rainy forest on lowland <1000m; medium and low hilly and mountainous area with elevation from 700-2000m; high mountain of >2000m with high diversity that could be seen in Chu Yang Sin, Bi dup Nui Ba, Kon Ka Kinh, Chu Mom Ray, Ngoc Linh national parks and particularly this is habitat of a very typical <i>Dipterocarpus</i> forest ecosystem with dominant species as <i>Dipterocarpus obtusifolius</i> , <i>D.tuberculatus</i> , <i>Shorea roxburghii</i> and <i>Shorea siamensis</i> of which Yok Don national park is a representative. Needle leaved forest, mixed broad and needle leaved forest with <i>Pinus keisya</i> as a representative to be found in Da Lat plateau and Komplong, Dak Gley. Focal tasks on forest development are conservation of biodiversity and watershed and are seen as key region of large timber material production.

Sub-region	Indicator	Major characteristics
TV 30: Ngoc Linh mountain block at elevation of over 1000m	Climate	T _{year} : 17-22 °C; R _{year} : 2200-4000 mm
	Geomorphology	Massive mountain blocks foundation on primary terrain type with deep and horizontal cleavage and sloppy hill. Topography tends to gradually lower from north to south, northeast to southwest. The sub-region's elevation is taken from the belt of 1600 – 1700m up in southwest part (including low and medium mountain blocks).
	Soil	Mainly Humic ferralsols and various Acrisols, including Humic acrisols, Gleyic acrisols, Ferralic acrisols on granite, gnai ground to be formed through feralit mud and alit process with medium layer and relative fertility and mud.
	Forest vegetation	Main forest type is evergreen broad leaved, closed, mixed and rainy forest on low and medium mountain of 700-2000m and high mountain of >2000m: at the elevation below 1000m, forest vegetation is highly intervened. + Evergreen broad leaved, closed, mixed and rainy forest on low and medium mountain of 700-2000m is formed by broad leaved timber species of different families as Fagaceae, Lauraceae with dominant species as <i>Lithocarpus</i> spp., <i>Quercus</i> spp., <i>Cinnamomum</i> spp. Forest cover is rather high, from 70-80% with rich timber volume from 180-250m³/ha, productivity of 12-14m³/ha/year. - Evergreen broad leaved, closed, mixed and rainy forest on high mountain over 2000m is rarely intervened and remained intact. It is formed by various species from families of Lauraceae, Fagaceae, Theaceae, Araliaceae, Magnoliaceae, Aceraceae... Dominant species are <i>Pentaphylax</i> spp., <i>Quercus</i> spp., <i>Lithocarpus</i> spp., <i>Castanopsis</i> spp., <i>Litsea verticillata</i>, <i>Symplocos cochinchinensis</i>, <i>Eurya japonica</i>, <i>Elaeocarpus</i> spp., <i>Exbucklandia tonkinensis</i>, <i>E. populnea</i>, <i>Turpinia montana</i>... In addition, there are also some other species as <i>Podocarpus imbricatus</i>, <i>P. neriifolius</i>, <i>Pinus dalatensis</i>, <i>Dacrydium elatum</i>, <i>Amentotaxus poilanei</i>... Forest cover is from 60-70% with high timber volume of 130-150m³/ha, productivity from 7-8m³/ha/year. From elevation from 1800-2000m up, there are <i>Rhododendron</i> spp., <i>Forkienia hodginsii</i>, <i>Illicium</i> spp.,. Timber volume is low, from 70-90m³/ha.
TV 31:	Climate	T _{year} : 20-26 °C; R _{year} : 1600-2000 mm

Sub-region	Indicator	Major characteristics
Sa Thay low mountain	Geomorphology	Including low mountain range that spread towards north-east-southwest direction. Low massive mountain block at average elevation from 600-700m. There are also some peaks that are at the elevation of more or less 1000m, with strong division and stiff slope.
	Soil	Mainly Rhodic ferralsols, Ferralic Acrisols, Humic Acrisols on acgilit, clay shale, granite and old alluvium to be formed through feralit process with thick layer and medium mud.
	Forest vegetation	- Evergreen broad leaved, closed, mixed, rainy forest on low and medium mountain from 700-2000m on Sa Thay low mountain with main species as <i>Canarium</i> spp., <i>Elaeocarpus</i> spp., <i>Paviesia annamensis</i>, <i>Gironiera subaequalis</i>, <i>Agalia</i> spp. and various genus of different families as Lauraceae, <i>Ormosia</i> spp., <i>Cratoxylon</i> spp.... Forest cover is from 60-70% with average timber volume from 130-160m³/ha. - Evergreen broad leaved, closed, mixed, rainy forest on low mountain below 1000m distributed in Kon Tum low land in the mixture with semi-deciduous mixed forest (corridor forest along river, stream bank) and bamboo and mixed timber-bamboo forest as results of the degraded evergreen broad leaved, closed, mixed, rainy forest on low land as mentioned above due to human being's intervention. Average timber volume if forest type 1a is from 140-180m³/ha.
TV 32: Basalt plateau PleiKu, Kon Hà Nừng	Climate	T _{year} : 20-24°C; R _{year} : 1800-2200 mm
	Geomorphology	There are 2 plateaus, of which Pleiku is a young, medium to low dissected plateau at average elevation of 700m – 800m while, Kon Ha Nung is an old, strong dissected plateau at average elevation of 900-1000m.
	Soil	Mainly Haplic nitisols, Humic Acrisols, Ferralic Acrisols on basalt, granite, acgilit, clay shale to be formed through feralit and mud feralit process. Soil layer is from thick to medium with rather high fertility and mud.

Sub-region	Indicator	Major characteristics
	Forest vegetation	- Evergreen broad leaved, closed, mixed, rainy forest on low and medium mountain is at elevation from 700-2000m and mainly distribute in Kon Ha Nung plateau with diversified species: at the elevation from 500-800 m, dominant species are belonging to different families such as Mangnoliaceae with <i>Michelia mediocris</i>, <i>Aglaia balansae</i>; Meliaceae with <i>Aglaia</i> spp.; Anacardiaceae with <i>Gluta</i> spp.; Fabaceae with <i>Dialium cochinchinense</i>... At the elevation from 600-2000m, it is characterized by the transition between families distributed at low area into those that adapt to higher areas such as families of Lauraceae, Fagaceae with fewer families as Meliaceae, Dipterocarpaceae. Average volume of this forest type is rather high from 160-250 m³/ha. - Evergreen broad leaved, closed, mixed, rainy forest on high mountain >2000m is dominant by humid demanding, cold resistant species as <i>Quercus</i> spp., Species of Ericaceae and Theaceae family are often low and bent trees with low volume of less than 80 m³/ha. - Semi deciduous mixed forest that distributes at low land where sand accounts to a large proportion. Typical species of various family such as Dipterocarpaceae with <i>Hopea odorata</i>, <i>Hopea</i> spp....; Fabaceae with <i>Sindora</i> spp., <i>Pterocarpus macrocarpus</i>; Ericaceae with <i>Lagerstroemia</i> spp., with average volume from 100-200 m³/ha. Flora vegetation is seriously degraded on Pleiku plateau. Deciduous humid tropical forest and secondary savanna are dominant with various species as <i>Lithocarpus</i> spp., <i>Lagerstroemia</i> spp., <i>Dipterocarpus obtusifolius</i>, <i>Shorea siamensis</i>... Productivity is from 6-7m³/ha/year. - Popular plantation forest species are <i>Acacia</i> spp., <i>Eucalyptus</i> spp., <i>Pinus kesiya</i> and <i>Litsea</i> sp....
TV 33: An Khê low mountain (Trian mountain)	Climate	T _{year} : 23-25 °C; R _{year} : 1500-2000 mm
	Geomorphology	Low massive block mountain founded on intrusion and eruptive rocks at the elevation from 600-700m. There are some peaks at the elevation of more or less 1000m with strong division and stiff slope.
	Soil	Mainly Humic acrisols, Gleyic acrisols, Distric fluvisols on ground of granit, old alluvium, degraded shale, accgilit to be formed through feralit and humid feralit process. Soil layers are from medium to low with poor fertility and mud in addition to strong erosion and high acid.

Sub-region	Indicator	Major characteristics
	Forest vegetation	- Evergreen broad leaved, closed, mixed, rainy forest on low mountain <1000m in addition to medium and low hill and mountain at the elevation from 700-2000m with ecological dominant species as <i>Anisoptera cochichinensis</i>, <i>Cinnamomum</i> sp, <i>Aphanamixis grandiflora</i>. - Thin, dry and seasonal deciduous forest dominated by Dipterocarpus family oriented species and closed, mixed, semi-deciduous forest (transition between the above mentioned evergreen broad leaved, closed, mixed, rainy forest on low mountain and the thin, dry, seasonal deciduous forest dominated by Dipterocarpaceae family oriented species).
TV 34: Cheo Reo – Phú Bồn – Ea sup semi-plateau	Climate	T _{year} : 25-27 °C; R _{year} : 1200-1800 mm
	Geomorphology	Denuded, accumulated and low dissected plain topography with average elevation from 500-1000m. Cheo Reo - Phu Tuc area is dominated by stairs and alluvium related topography.
	Soil	Mainly Distric fluvisols, Gleyic acrisols, Rhodic ferralsols on ground of old alluvium, clay shale, acgilit, basalt, granit to be formed through feralit and alluvium process. Soil layer, mud and fertiltly are at medium level.
	Forest vegetation	- Thin, dry and seasonal deciduous forest dominated by Dipterocarpus family with dry climate adapted species such as <i>Dipterocarpus obtusifolius</i>, <i>D. tuberculatus</i>), <i>Shorea roxburghii</i>, <i>S. siamensis</i> and some of Combretaceae family as <i>Terminalia triptera</i>, <i>T. corticosa</i>. This forest type has simple composition of 1-2 timber layers with thin density and average timber volume of 40-80m³/ha. - Mixed forest on limestone is transitioning forest (corridor) along large rivers, streams with dominant species as <i>Lagestroemea</i> spp., <i>Sindora cochinchinensis</i> and <i>Pterocarpus indicus</i>.
TV 35: Buon Ma Thuot Bazalt plateau	Climate	T _{year} : 23-25 °C; R _{year} : 1600-2000 mm
	Geomorphology	Young basalt and less dissected plateau with average elevation from 500m-600m and gradually sloping down from north to south, west to east.
	Soil	Mainly Ferralic acrisols, Gleyic acrisols, Rhodic ferralsols on ground of bazalt, granit, old alluvium, shale, accgilit to be formed through feralit process. Soil layers are from thick to medium with rather high fertility and mud.

Sub-region	Indicator	Major characteristics
	Forest vegetation	There remain small area of natural vegetation but mainly population of <i>Lagestroemia</i> spp., <i>Dipterocarpus obtusifolius</i> of type 2 and 5. Plantation forest is dominated by <i>Pinus keisya</i> , <i>Acacia</i> spp., <i>Senna siamea</i> and <i>Tectona grandis</i> .
TV 36: M'Drak mountain block	Climate	T _{year} : 22-24 °C; R _{year} : 1600-2200 mm
	Geomorphology	Waving hilly topography with average elevation of 400m. There are some mountain blocks in the east of 700-800m.
	Soil	Mainly Ferralic Acrisols, Gleyic Acrisols, Humic Acrisols on ground of granit, acgilit, clay shale, degraded shale, old alluvium to be formed through feralit and mud feralit process. Soil layers are from medium to thin depth with strong erosion, outcrop rocks and medium fertility and mud.
	Forest vegetation	- Evergreen broad leaved, closed, mixed, rainy forest on medium and low mountain, which mainly is distribute at the elevation of over 700m. Flora composition is dominated by families of Dipterocarpaceae, Lythraceae, Fagaceae, Lauraceae, Myrtaceae, Euphorbiaceae, Fabaceae, etc. at the elevation of over 1000m with various species as <i>Quercus bambusaefolia</i>, <i>A. tonkinense</i>, some species belonging to other genus as <i>Litsea</i>, <i>Cinnamomum</i>, <i>Elaeocarpus dubius</i>, <i>Michelia</i> spp.. At higher elevation, there appears forest type 4 with presence of needle leaved species as <i>Dacrycarpus imbricatus</i> and <i>Dacrydium elatum</i>. - Evergreen, closed, mixed, rainy forest on low mountain below 1000m dominated by different families as Meliaceae, Euphorbiaceae, Lauraceae, Rutaceae, Rosaceae, Fabaceae, Fagaceae, Moraceae... There are also representatives of Combretaceae family and some deciduous species as <i>Lagerstroemia tomentosa</i> of Lythraceae family and <i>Tetrameles nudiflora</i> of Datisceae family. - Bamboo and mixed timber, bamboo forest rehabilitated after cultivation and over-exploited with main species as <i>Pseudoxytenanthera nigrociliata</i>, <i>P. hosseusii</i>, <i>Bambusa procera</i>, <i>Neohouzeana dulloa</i> and some scattered remaining broad leaved species as <i>Quercus</i>, <i>Lithocarpus</i>, <i>Castanopsis</i>, <i>Endospermum chinense</i>, <i>Pterocellobium clyapea</i>, <i>Gnema</i>, <i>Canarium sinense</i>, <i>Gironniera subaequalis</i>, <i>Macaranga denticulate</i> etc.

Sub-region	Indicator	Major characteristics
		- In addition, there exist also grass vegetation distributed on unfertile and gravel soil with drought resistance species as <i>Miscanthus sinensis</i> , <i>Memecylon fruticosum</i> , <i>Melastoma candidum</i> , <i>Imperata cylindrica</i> , <i>Erianthus arundinaceus</i> , <i>Phragmites sp.</i>
TV 37: Đăk Nông – Đăk Min plateau	Climate	T _{year} : 22-24 °C; R _{year} : 1600-2600 mm
	Geomorphology	Eroded and strongly dissected old basalt plateau with average elevation of 700-800m, the highest peak is 1187m. Being an arch plateau, topography is sloping down on different sides.
	Soil	Mainly Ferralic Acrisols, Xanthic Ferralsols, Rhodic Nitisols on ground of argillite, clay shale, degraded shale, granite, basalt, Haplic Andosols to be formed through feralit process. Soil layer is from thick to medium with rather high fertility and mud.
	Forest vegetation	- Evergreen broad leaved, closed, mixed, rainy forest on low mountain below 1000m; there remain small area of forest distributed on low and medium hill, mountains of 700-2000m from Chu Dju to Vong Phu range with dominant species as <i>Hopea</i> spp., <i>Shorea</i> spp., <i>Michelia</i> spp, <i>Dipterocarpus</i> spp.... with timber volume from: 120-150m ³ /ha. - Plantation forest with main species as <i>Acacia</i> spp., <i>Eucalyptus</i> spp. and <i>Pinus</i> spp..
TV 38: Chư Ang Sin mountain block and Đà Lạt plateau	Climate	T _{year} : 16-25 °C; R _{year} : 1500-2200 mm
	Geomorphology	Massive mountain block foundation oriented terrain type with deep and horizontal cleavage and sloppy hill (Chư Yang Sin mountain block) and denuded highland (Đà Lạt). The sub-region's elevation is taken from the belt of 1000m up, average elevation of 1000- 1700. However, there are some peaks of over 2000m.
	Soil	Mainly Ferralic Acrisols, Humic Acrisols distributed alternatively with Distric Fluvisols, Xanthic Ferralsols, Rhodic Nitisols on ground of argillite, clay shale, degraded shale to be formed through feralit process. Soil layer is from thick to medium with rather high fertility and mud

Sub-region	Indicator	Major characteristics
	Forest vegetation	Below the elevation of 800m, there distributed evergreen broad leaved, closed, mixed, rainy forest with dominant species as <i>Hopea odorata</i>, <i>Dipterocarpus alatus</i> and <i>D. turbinatus</i>. The forest type 2 is dominated by <i>Lagestroemia calyculata</i> and <i>Terminalia nigrovenulosa</i>. From the elevation over 800m, there distributed evergreen broad leaved, closed, mixed, rainy forest on low and medium mountain with typical species from Fagaceae and Lauraceae families. Needle leaved, mixed needle and broad leaved forest which is characterized by rich and diversified needle leaved species as <i>Pinus dalatensis</i>, <i>P. krempfii</i>, <i>P. kesiya</i> var. <i>langbianensis</i>, <i>Podocarpus imbricatus</i>, <i>Fokienia hodginsii</i>. On top of mountain and high mountain slope, there appears short forest ecosystem with dominant species as <i>Lyonia annamensis</i>, <i>L. ovalifolia</i> and some small <i>Arundinaria</i> spp.. Other typical secondary forest in this area is relatively dry needle leaved forest dominated by <i>P. kesiya</i>. Secondary bamboo and rattan forest in the area also develop on large area with 2 dominant species as <i>Oxytenanthera nigrociliata</i> and <i>Bambusa procera</i>.
TV 39: Di Linh, Bảo Lộc plateau	Climate	T _{year} : 20-22 °C; R _{year} : 1500-2800 mm
	Geomorphology	Denuded basalt plateau oriented topography that locates alternatively with the remaining hilly mountains. Average elevation is from 850-1000m, sloping from north-east to south-west. Topography is rather plain and accounts 75% of the total area in the sub-region.
	Soil	Mainly Rhodic ferralsols, Ferralic Acrisols, Gleyic Acrisols on the ground of basalt, granit. acgilit, clays shale, degraded shale to be formed through mud feralit process. Soil layer is thick with rather high fertility and mud.
	Forest vegetation	Needle leaved, mixed broad and needle leaved forest with typical species as <i>Pinus kesiya</i> and sometime mixed with some broad leaved species as <i>Dipterocarpus obtusifolius</i>, <i>Quercus</i> spp., etc. Type 1c is dominated by species belonging to different families as Fagaceae, Euphorbiaceae, Lauraceae) and Fabaceae, etc.

Sub-region	Indicator	Major characteristics
VII. South-east region	Climate	Being influenced from tropical and marine equatorial air, it is typical tropical climate without winter and spring is the hottest period. Climate is strongly divided with T_{year} : 24-27°C. Sea is highly influenced from the east and south direction. BDT_{day} : 7-10 °C; BDT_{year} : 4-6°C. Heavy rain, R_{year} : 1400-2800mm, reducing gradually from north to south with 2 distinguished seasons of which the dry season is rather severe and spreads over the winter-spring period. The region is less influenced from storm.
	Geomorphology	Cascade topography represented by low mountain in the north, then hilly and finally Dong Nai and Sai Gon river plain.
	Soil	Mainly Lixisols, Rhodic ferralsols, Gleyic acrisols that are strongly eroded and laterized. In addition, there are also District fluvisols, Gleyic fluvisols with reduced fertility and productivity potential.
	Forest vegetation	Evergreen broad leaved, closed, mixed, rainy forest on low mountain below <1000m with dominated species as <i>D. alatus</i> , <i>D. dyeri</i> , <i>Hopea odorata</i> , <i>Hopea</i> spp, <i>Anisoptera cochichinensis</i> with high timber volume and productivity. In the south-east hilly mountain sub-region mangrove is typical species of coastal mangrove forest. Plantation forest with key species as <i>Acacia</i> spp., <i>Eucalyptus</i> spp., <i>Tectona grandis</i> , <i>Dipterocarpus</i> spp., etc. with higher productivity in comparison with other regions. Forest development objective is to consolidate watershed protection forest system, urban protection and development of material zones for timber, paper and sawn timber so as to serve local processing industry in the region.
TV 40: Low mountain in south-east region (Binh Phuoc, Dong Nai)	Climate	T_{year} : 25-27 °C; R_{year} : 1800-2800 mm
	Geomorphology	Massive mountain block foundation oriented terrain type with deep and horizontal cleavage and sloppy hill. Average elevation is below 1000m
	Soil	Mainly Xanthic ferralsols, Rhodic ferralsols, Ferralic acrisols on the ground of acgilit, clay shale, degraded shale, old alluvium, granit, bazalt to be formed through feralit process. There exist strong erosion and laterit with medium and thin soil layer of medium fertility and mud.

Sub-region	Indicator	Major characteristics
	Forest vegetation	Evergreen broad leaved, closed, mixed, rainy forest in low mountain below <1000m and dominated by typical species as <i>D. alatus</i> , <i>D. dyeri</i> , <i>Hopea odorata</i> , <i>Hopea</i> spp.... Plantation forest with main species as <i>Acacia</i> spp., <i>Eucalyptus</i> spp., <i>Hopea odorata</i> , <i>Tectona grandis</i> ... Plantation forest productivity could reach from 20-30 m ³ /ha/year.
TV 41: Hilly area in south-east region	Climate	T _{year} : 26-27 °C; R _{year} : 1600-2200 mm
	Geomorphology	It is hilly topography at the elevation from 100-120m, with slopping arch oriented peak or linkage arches with large and plain valleys between hills. Unclear hilly directions, which could be reflected through the confusion of hydrometeorology network direction in the sub-region.
	Soil	Mainly Ferralic Acrisols that distributes alternatively with other soil types on the ground of granit, old alluvium, basalt, and is likely to be formed through feralit process. Soil layers are from medium to thin with strong erosion and lateritized, acid in addition to large conglomerated laterite, low fertility and mud.
	Forest vegetation	Evergreen broad leaved, closed, mixed, rainy forest on lowland in southern part with dominated species from Dipterocarpaceae family, which is represented by lowland oriented species as <i>Dipterocarpus alatus</i> , <i>D. dyeri</i> , <i>Hopea odorata</i> , <i>Hopea</i> spp. However, forest is strongly intervened and degraded into human being intervened secondary forest and mainly transferred into plantation forest with main species as <i>Eucalyptus</i> , <i>Acacia</i> , <i>Tectona grandis</i> in addition to some other indigenous species. Plantation forest productivity in the sub-region could reach 20-30m ³ /ha/year.
TV 42: South-east delta	Climate	T _{year} : 26-27 °C; R _{year} : 1400-2000 mm
	Geomorphology	Dong Nai, Sai Gon river delta at the elevation below 10m.
	Soil	Mainly Gleyic fluvisols, Distric gleysols that locate alternatively with Ferralic Acrisols, Gleyic Acrisols, Protothionicgleysols. This soil type distributed on fragmented area with acid with low fertility.
	Forest vegetation	Evergreen broad leaved, closed, mixed, rainy forest on low mountain <1000m with some typical species as <i>D. alatus</i> , <i>D.</i> , <i>Hopea odorata</i> , <i>Hopea</i> spp., etc. Plantation forest is dominated by <i>Hopea odorata</i> , <i>acacia</i> , <i>Eucalyptus</i> spp., <i>Tectona grandis</i> , etc. Plantation forest productivity could reach from 20-30m ³ /ha/year.

Sub-region	Indicator	Major characteristics
TV 43: Coastal mangrove forest in south-east region (Cần Giờ)	Climate	T _{year} : 26-27 °C; R _{year} : 1400-1800 mm
	Geomorphology	Coastal tidal flat is flooded according to tidal regime, refined material that creates large strip.
	Soil	Mainly Rhodic arenosols, Thionic fluvisols, Solonchak and Gley solonchaks that distribute alternatively with some other soil types on the ground of coastal and river gate alluvium of Can Gio – Ba Ria Vung Tau. Soil is acid, clay with medium fertility and mud.
	Forest vegetation	Coastal mangrove forest with flora community and population, including: Mono <i>Sonneratia alba</i> population on deeply flooded newly established tidal flat; <i>Rhizophora apiculata</i> and <i>S. alba</i> community on stable alluvium; <i>R. apiculata</i> and <i>Xylocarpa granatum</i> community on deeply (2-2.5m) flooded land (this is seen as the most popular community in the region; <i>R. apiculata</i> and <i>Ceriops tagal</i> community on high tidal flooded land; <i>Avicenia officinalis</i> and <i>C. decandra</i> community on high tidal flooded area; <i>Excoecaria agalocha</i> and <i>Phoenix paludosa</i> community on very high tidal flooded area. Fresh flora community distribute along river bank, including: <i>S. caseolaris</i> community on 1-1.5 m tidal flooded area; <i>Cryptocoryne ciliate</i> , <i>erberactatus</i> and <i>Nypa fruticans</i> community on 1.5-2m tidal flooded areas; <i>Annona reticulate</i> and <i>Flagellaria indica</i> community on 2-3m tidal flooded areas; <i>Melastoma polyanthum</i> and <i>Dalbergia candenatensis</i> community on 4m tidal flooded areas.
TV 44: Côn Đảo	Climate	T _{year} : 25-27 °C; R _{year} : 1800-2200 mm
	Geomorphology	Island mixed with low mountain, hills and coastal sandy beach.
	Soil	Mainly Gley solonchaks, Thionic fluvisols with medium fertility.
	Forest vegetation	- Evergreen broad leaved, closed, mixed, rainy forest on low mountain below 1000m with typical species that have the island's names as: <i>Dipterocarpus condorensis</i>, <i>Ilex condorensis</i>, <i>Pavetta condorensis</i>, <i>Psychotrya condorensis</i>, etc. - Coastal mangrove forest mainly distributed around Hon Ba and along Con Dao's western coastal line. Mangrove forest in Con Dao is dominated by <i>Bruguiera gymnorhiza</i>, <i>Avicennia alba</i> and <i>Rhizophora mucronata</i>.

Sub-region	Indicator	Major characteristics
VIII. South-west region	Climate	Being influenced by tropical and marine equatorial air of monsoon regime. The climate is characterized as typical tropical monsoon without winter. Topography is rather homogeneous with low climate division. T_{year} : 26.5-27.5°C. $T_{\text{min}} > 10^{\circ}\text{C}$, $T_{\text{max}} < 40^{\circ}\text{C}$. Being directly influenced by the sea from different directions, therefore, BDT_{day} : 6-8°C, $\text{BDT}_{\text{year}} < 4^{\circ}\text{C}$. Heavy rain, R_{year} : 1400-3500mm, gradually increases toward northeast-southwest so as to create a heavy rainy center on western coastal area. Annually, there are 2 distinguished dry and rainy seasons that are suitable with operation of the 2 monsoon seasons. Although more than half of the bordering area is sea, it is not much influenced by storm (low intensity). There exists high radiation, which is not much different between regions and seasons.
	Geomorphology	Flat plain at the elevation below 10m, this topography is dissected by rivers and streams.
	Soil	Mainly Fluvisols of Mekong delta with high fertility and potential tropical wetland and Thionic fluvisols.
	Forest vegetation	Mainly coastal mangrove forest and Malaleuca forest. Establishment of protection forest system for sea wave prevention is seen as a focal task in this region.
TV 45: Southern region	Climate	T_{year} : 26-27 °C; R_{year} : 1400-1900 mm
	Geomorphology	Mekong delta at the elevation below 10m.
	Soil	Mainly Fluvisols with or without Gleyic, seasonal flooded Thionic fluvisols on alluvium of Mekong delta with rather high fertility and mud. There exist peatland area in Ca Mau, Kien Giang.
	Forest vegetation	There is <i>Melaleuca cajuputi</i> forest with <i>Phragmites vallatoria</i> and some other species belonging to <i>Eleocharis</i> spp. genus under forest canopy. Vascular plant vegetation are seasonal or regularly flooded grass vegetation, which could be divided into 4 main groups: - Grass vegetation in long period flooded brackish water area, which is dominated by <i>Eleocharis dulcis</i> , <i>Oryza rufipogon</i> and <i>P. vallatoria</i> . This vegetation status could be found in acid sulphate soils areas. - Grass vegetation on Thionic fluvisols is dominated by several species as <i>E. dulcis</i> , <i>E. ochrostachya</i> , <i>Ischaemum rugosum</i> and <i>Lepironia articulata</i> . These areas are often in deep seasonal flood.

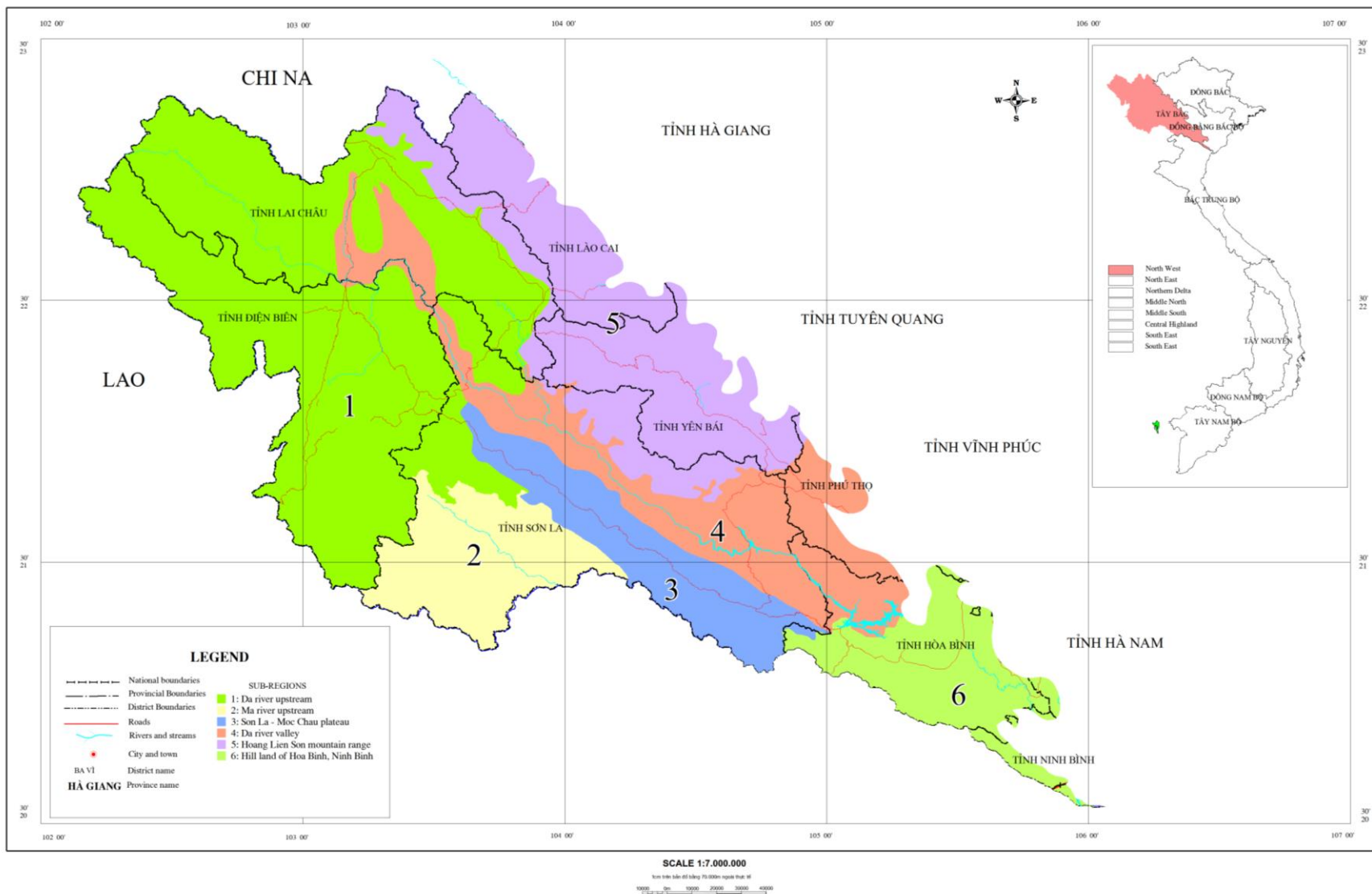
Sub-region	Indicator	Major characteristics
		- Grass vegetation on sandy soil or old Fluvisols is dominated by different species as <i>Eragrostis atrovirens</i>, <i>Setaria viridis</i>, <i>Mnesithea laevis</i>, <i>Panicum repnes</i>. These area are flooded for a short period. - Grass vegetation is influenced by brackish water with dominant species as <i>Paspalum vaginatum</i>, <i>Scirpus littoralis</i>, <i>Zoysia matrella</i>, <i>E. dulcis</i>, <i>E. spiralis</i>. These areas could be flooded (brackish water).
TV 46: Southwest wetland	Climate	T _{year} : 26-27 °C; R _{year} : 1800-2000 mm
	Geomorphology	Coastal tidal flat is flooded according to tidal regime, refined material to form constant large strips surrounding the delta.
	Soil	Mainly Solonchaks, Gley solonchaks with rich clay on coastal tidal Fluvisols and Mekong river gate with rather high fertility and mud.
	Forest vegetation	Coastal mangrove forest with the most diversified mangrove species in Vietnam in terms of both species quantity (richest), trees dimension (largest) and diversity of mangrove ecosystem (most diversified). Key mangrove communities are: <i>Avicennia marina</i> on strong or lightly acid sulphate soils developed on silty clay base that is submerged when medium or high tide comes; <i>A. officinalis</i> community on lightly silty clay base that is submerged when medium tide comes; <i>A. alba</i> community on newly alluvium on soft mud ground under low tidal flood; <i>Rhizophora apiculata</i> - <i>Brugiera parviflora</i> community on rather compressed clay ground, along canal and under medium tidal flood; <i>Avicennia alba</i> - <i>Rhizophora apiculata</i> on rather clammy muddy clay under medium tidal flood in river gate, canals, etc; <i>Lumnitzera racemosa</i> – <i>Ceriops tagal</i> community on high land; <i>Excoecaria agallocha</i> community on high land near the sea, <i>Phoenix paludosa</i> community on relatively compressed clay, which is hardly under tidal flood; <i>Nipa fruticans</i> community deeply locates inside canals with mainly brackish water.
TV 47: South-west island (Phu Quoc island)	Climate	T _{year} : 27-28 °C; R _{year} : 2000-3500mm
	Geomorphology	Typical topography is low mountain that distributes alternatively with hills and coastal sandy flats.
	Soil	Mainly Ferralic acrisols, Gleyic acrisols, Haplic calcisols on the ground of acgilit, clay shale, old alluvium, granit, denatured shale to be formed through feralit process. Soil layers are thick and medium with rather high fertility and mud.

Sub-region	Indicator	Major characteristics
	Forest vegetation	- Evergreen broad leaved, closed, mixed, rainy forest on low land in southern part with dominant species as Dipterocarpaceae with thick layers and mainly distributed in 3 areas: Ky Da river on Ham Ninh and Chao mountain ranges with main species as <i>Hopea odorata</i>, <i>Dipterocarpus dyerii</i>, <i>D. costata</i>, <i>Parinaria annamensis</i>, <i>Syzygium</i> spp. and <i>Dillenia ovata</i>... - Mangrove forest distributed in strips at ditches's gate, mainly at Tram ditch. Key species are <i>Rhizophora apiculata</i>, <i>Bruguiera gymnorhiza</i>, <i>Sonneratia alba</i>, <i>Lumnitzera racemosa</i>, <i>Excoecaria agallocha</i>. Specially, recently, there appear <i>Lumnitzera rosea</i>, which could not be found in other places in Mekong delta. - <i>Melaleuca cajuputi</i> is distributed in 3 topographical types: on regular flooded low land (dense <i>Melaleuca</i> growth with small dimension); on mixed Flovisols and clay area that is flooded during rainy season (<i>Melaleuca</i> growth in the mixture with large dimension and drought resistance grass); on stable sandy cultivation area, where flood could hardly appear (<i>Melaleuca</i> growth alternatively with other species of small dimensions). - Mixed forest on limestones distribute on high mountainous area with stiff rocky slope and could be seen on top of Chao, Ham Ninh, Ham Rong mountain at the elevation of 2250m. There remain considerable primary characteristics but forest trees have so small dimension due to severe growing conditions. 3 main dominances are often found as <i>Psidium</i> – <i>Calophyllum</i> - <i>Hopea</i>; <i>Calophyllum</i> – <i>Syzygium</i> – <i>Hopea</i>; <i>Memecylon</i> - <i>Aidia</i>

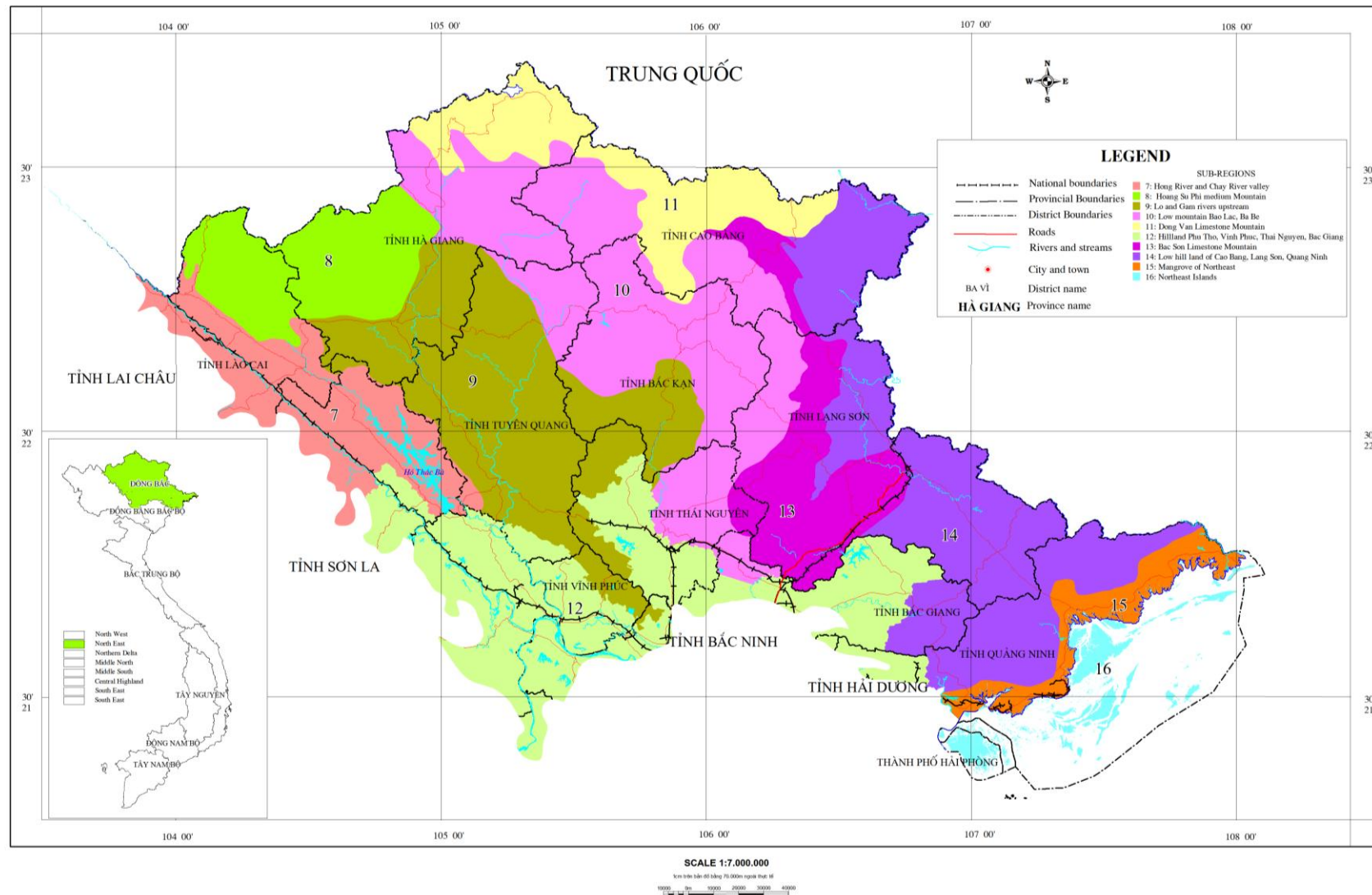
Remarks:

Tyear: annual average temperature (°C); Tmin is minimum temperature (°C); Tmax is maximum temperature (°C); BDTday is daily temperature amplitude (°C); BDTyear is annual temperature amplitude (°C); Ryear is total annual precipitation (mm).

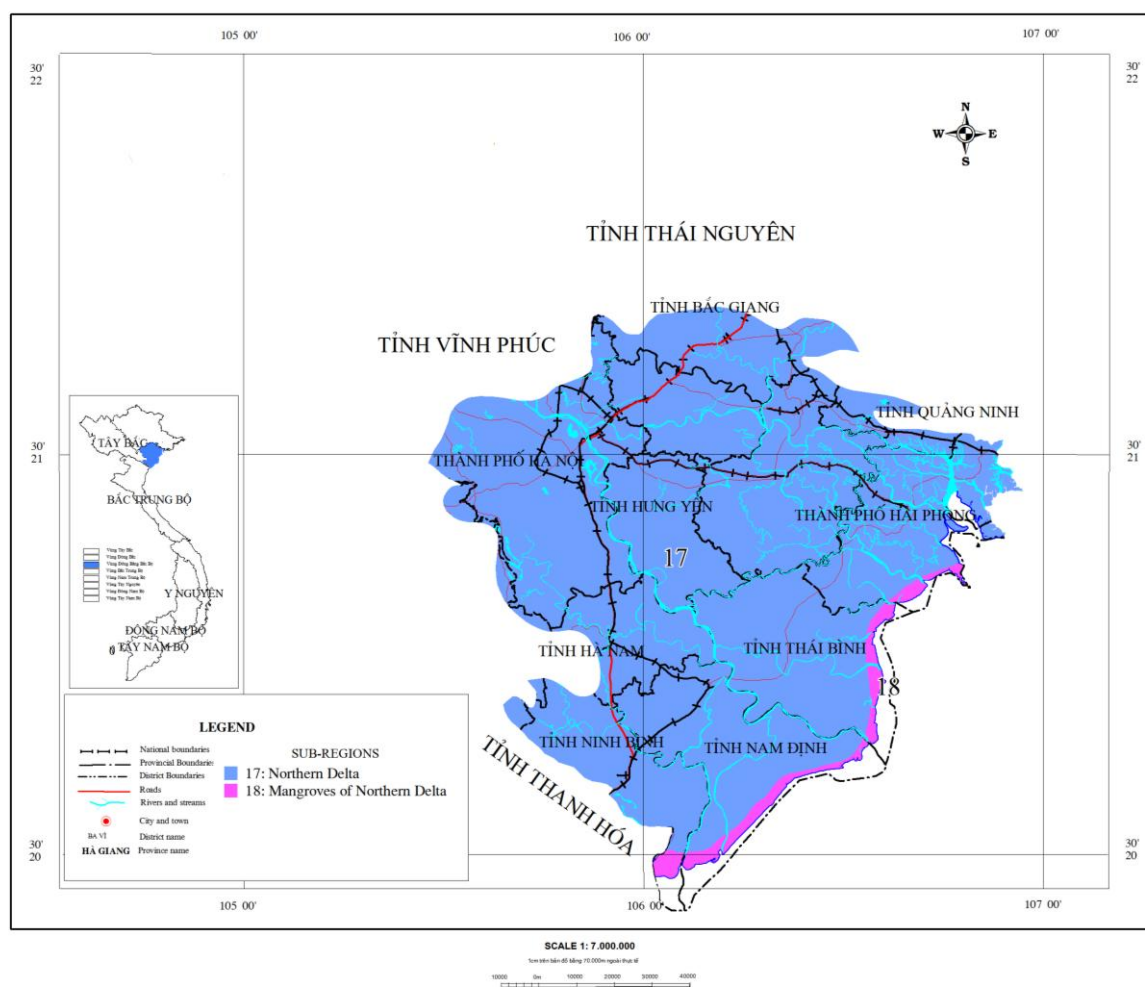
Annex 5. Forest eco-regions stratification map of Northwest



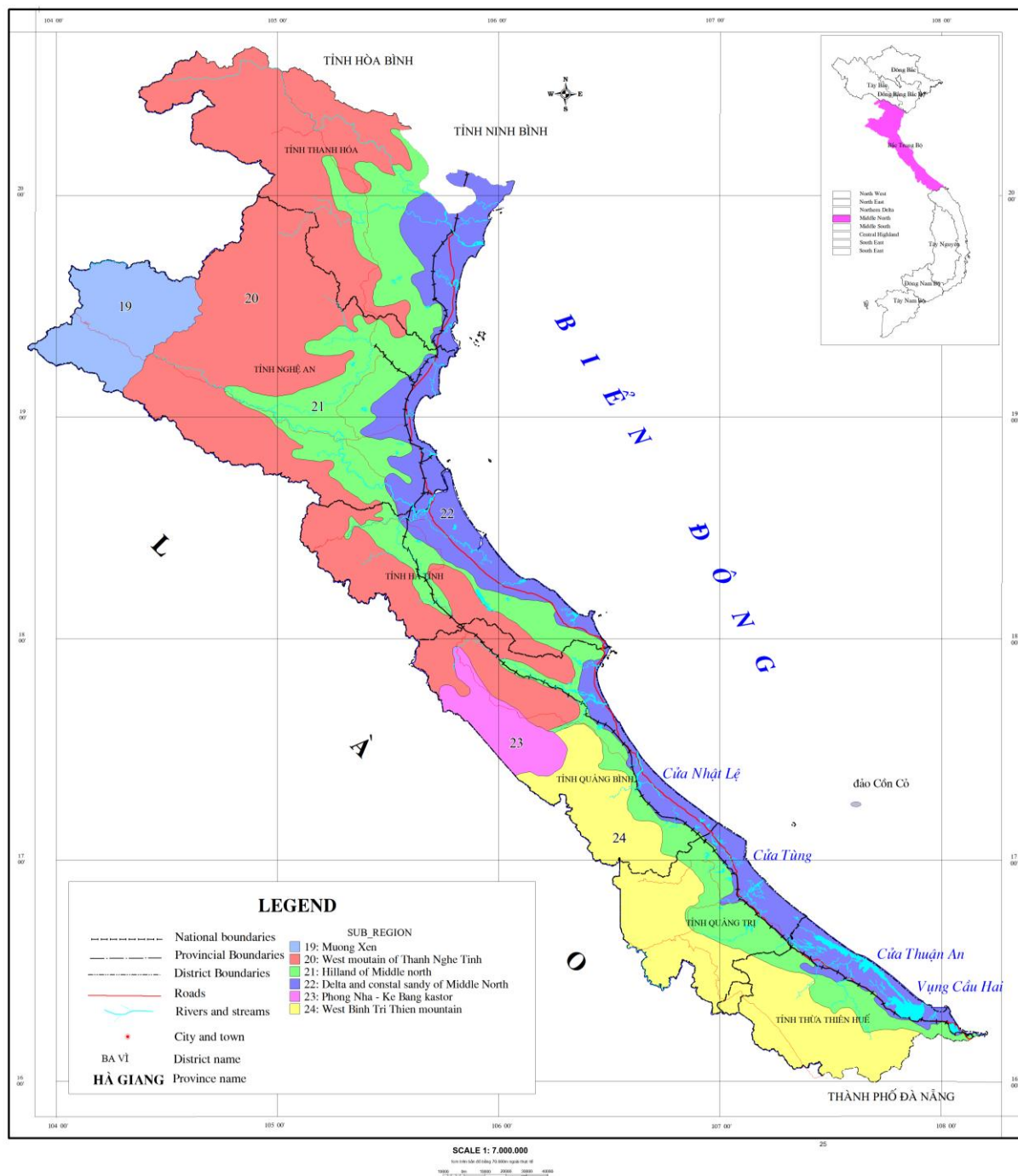
Annex 6. Forest eco-regionl stratification map of Northeast



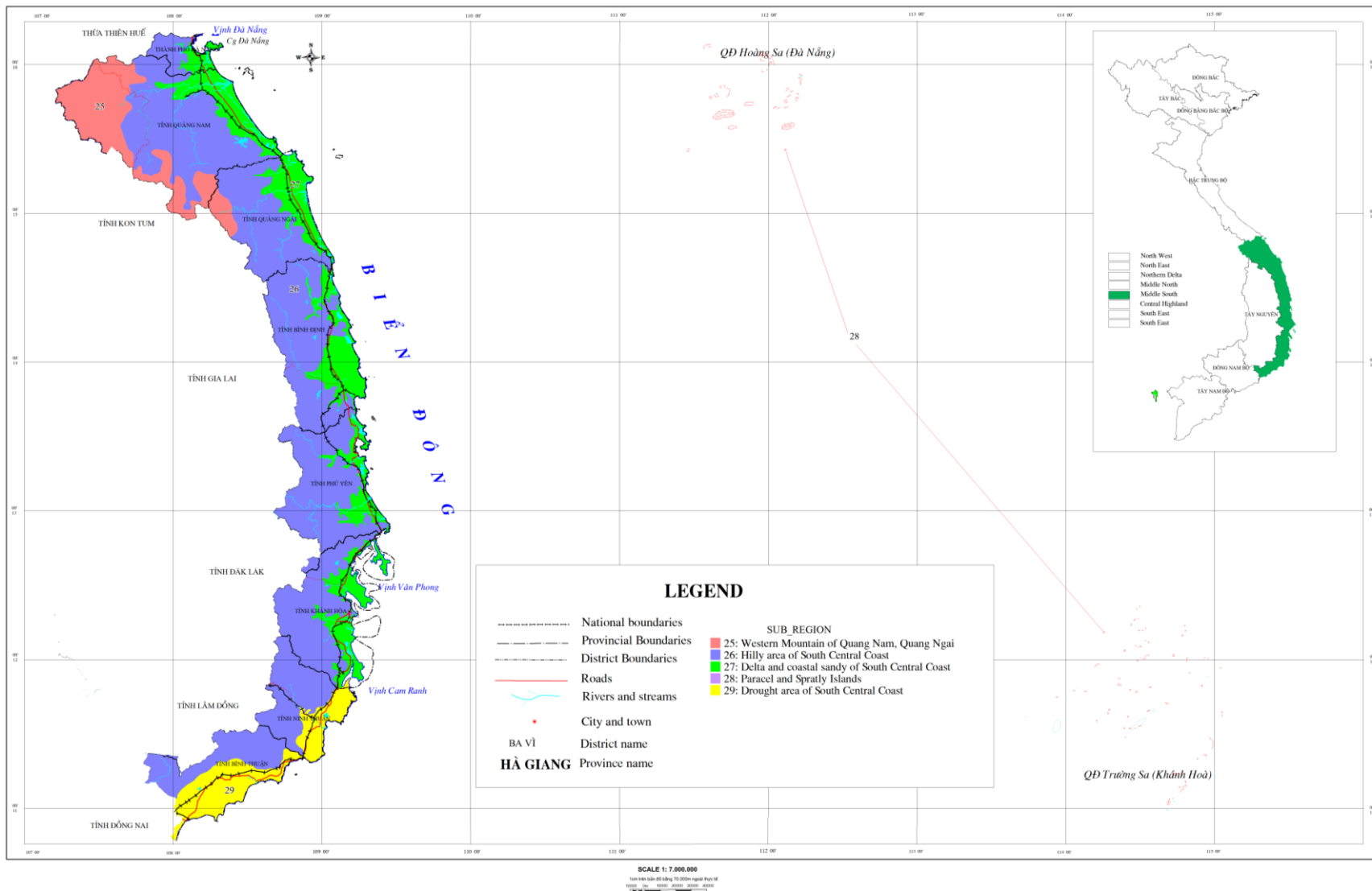
Annex 7. Forest eco-regions stratification map of Red river delta



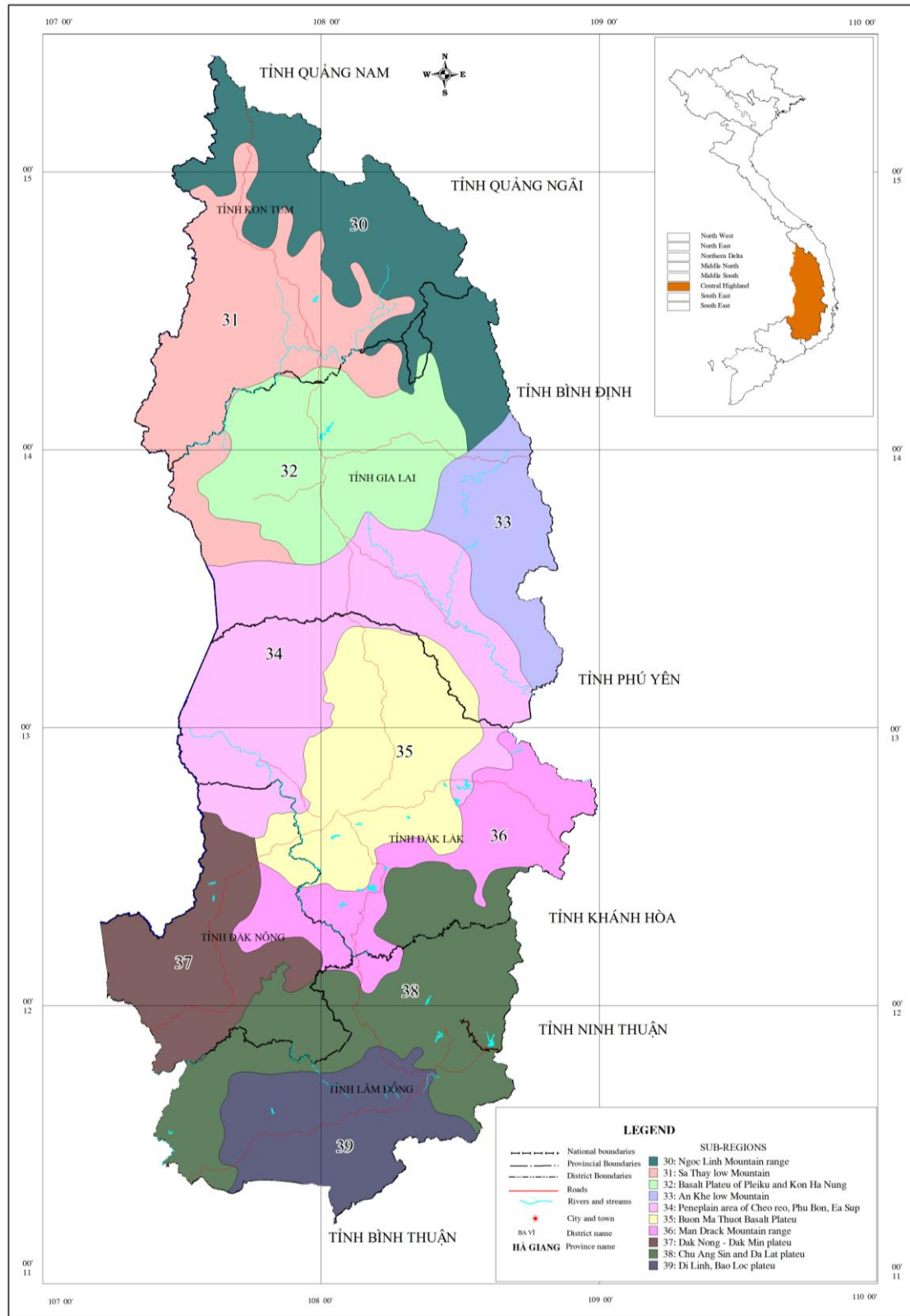
Annex 8. Forest eco-regions stratification map of North Central Coast



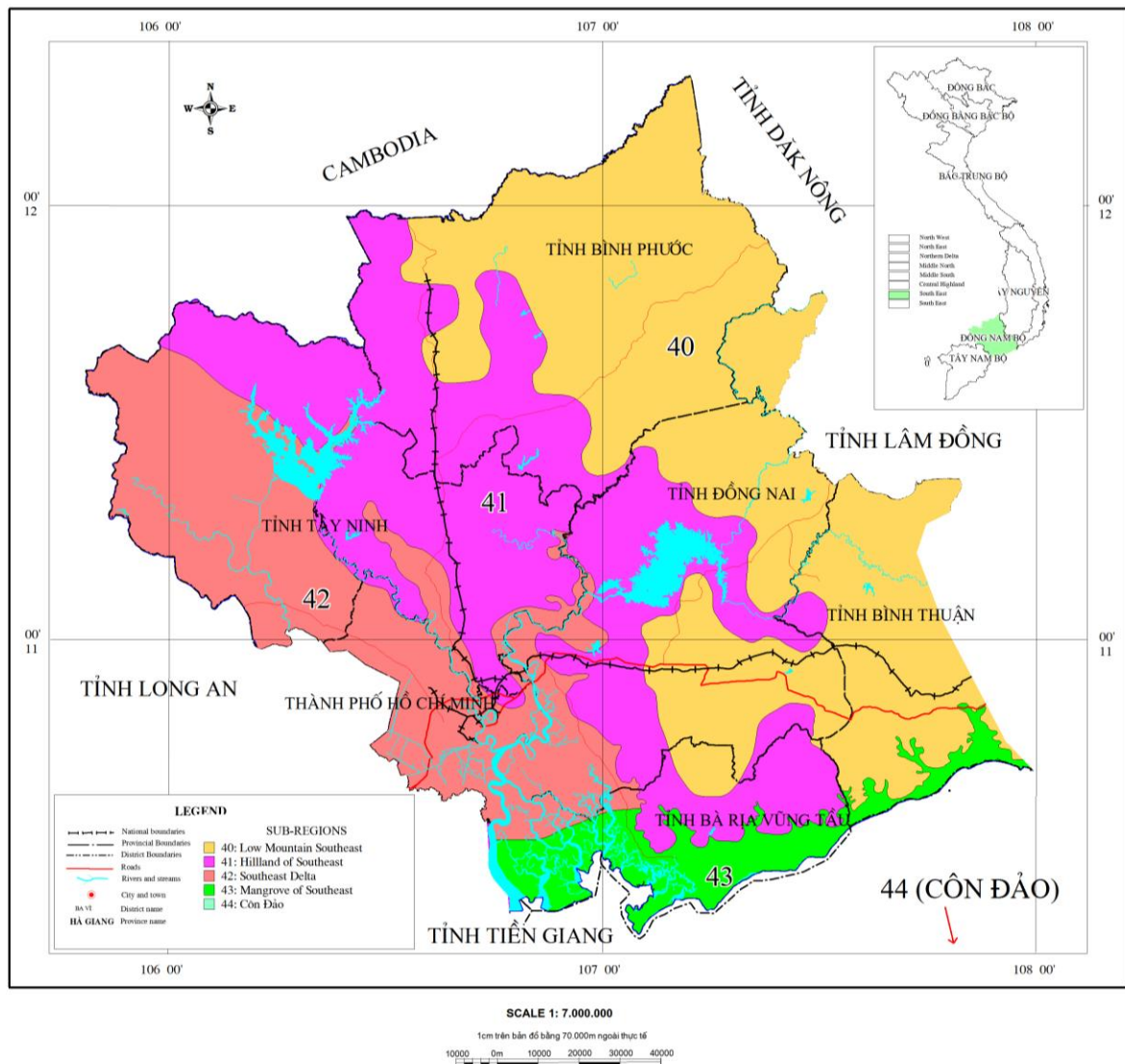
Annex 9. Forest eco-regions stratification map of South Central Coast



Annex 10. Forest eco-regions stratification map of Cental Highland



Annex 11. Forest eco-regions stratification map of Southeast



Annex 12. Forest eco-regions stratification map of Southwest

